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German Astronomy during the War

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I Introduction

In Germany a fair amount of astronomical research has been carried out during the war, of which the solar research is the most conspicuous. A number of new solar observatories were built, one at Göttingen and four in the Alps. The work at the Potsdam, Babelsberg, Hamburg, Heidelberg, and Munich observatories continued, though on a diminished scale, and also the work at the Rechen-Institut.

During 1944 and early 1945 some of the eastern German observatories were evacuated while others (Leipzig, Munich, and Königsberg) were severely damaged or destroyed. Recently astronomical research has been resumed on a limited scale in a few institutions, but because of the great material destruction in Germany and the drastic reduction in tax income it may be expected that the volume of work produced in the near future will be small.

The principal data of this article are arranged by institutions. Most of the information was obtained in personal visits during the period April-September, 1945. Some observatories were visited more than once; in general the "epoch" of the information is about September, 1945.

References to the astronomers' political activities and attitudes are omitted here, though they should eventually determnie post-war relations. For the same reason the position of the Astronomische Gesellschaft is not discussed here. A few general remarks are found in section V.

II Astronomisches Rechen-Institut

The Rechen-Institut corresponds to the U. S. or British Nautical Almanac Offices. Before the war a division of work was effected between the five principal almanac offices of the world in order to avoid duplication of large computational programs. This division and collaboration has remained in effect throughout the war. The exchange was accomplished through the intermediary of Professor Lindblad of Stockholm, Sweden.

The Rechen-Institut corresponds to the U. S. or British Nautical minor) functions and publications. The major publications are:

1. Berliner Jahrbuch
2. Kleine Planeten
3. Astronomischer Jahresbericht
4. Astronomische Nachrichten

In August, 1944, the Rechen-Institut was evacuated from Berlin to Sermuth near Grimma in Saxony, a town divided in two by the Mulda River. When the Mulda River became the provisional frontier between the Russian and U. S. zones of conquest, the institute was on the U. S. side and part of the staff on the Russian side. Subsequently the institute and some of its staff moved to Heidelberg, where the director, Professor Kopff, had worked for nearly twenty years. With him are the following staff members: K. Heinemann, F. Gondolatsch, E. Rabe, Miss H. Nowacki, and K. Henne.

At present, at Heidelberg only the bare essentials exist for continued work: certain manuscripts, tables, computing machines, and a few books, while the financial difficulties are grave. Not taken from Sermuth were the greater part of the library and the stock of publications by the institute held there.

The library is distributed in four localities; the original institute at Berlin-Dahlem; the Potsdam Observatory; the Sermuth, Saxony, evacuation buildings; and a castle near Heilbronn (in the U. S. zone). The last named place contains the old series of the *Astronomische Nachrichten* (since 1820) and of the *Berliner Jahrbuch* (since 1754).

The stock of the institute's publications is also scattered in four places: Berlin-Dahlem, Sermuth, Potsdam, and the printer at Halle an der Saale (Druckerei des Waisenhauses), all in the Russian zone now.

The U. S. has received the Star Positions for the *Berliner Jahrbuch* for 1945, 1946, and 1947; the 1948 and 1949 positions have been computed and exist in manscript form.

The complete *Jahrbuch* for 1945 has been distributed on a small scale (Germany, Switzerland, Sweden); 1946 has been printed and lies ready at Halle, at the printer's address given above. 1947 has been partly printed (star positions), the part sent to the U. S. and Britain. But two parts of the data have not yet been received from the U. S., "Eclipses" and "Astronomical Phenomena." The manuscript, except for the two missing parts, is at Heidelberg. 1948 has been printed in small part, and is at Halle. Another part is there in manuscript form, while a third part is in manuscript form at Heidelberg. But it is incomplete. The 1949 "Positions" are in manuscript form at Halle.

The *Kleine Planeten* for 1944 have been distributed; 1945 is at Halle, printed; 1946 is mostly ready in manuscript; the completed part is at Heidelberg. Some small parts are not available, because the collaborating computers are scattered and out of reach. 1947 has not yet been started.

The "Literature for 1941" in *Astronomischer Jahresbericht,* Vol. 43,

appeared in 1944. Some of the copies have been distributed and some are still in Berlin at the printers, Walter de Gruyter.

The "Literature for 1942" exists in manuscript form at Heidelberg, nearly finished. The author, Dr. Heinemann, is at Heidelberg. The "Literature for 1943" has not yet been started, since there is not enough non-German literature available at Heidelberg to make such work now possible.

The latest issues of the *Astronomische Nachrichten* are at the printers, in Halle.

The future of the Rechen-Institut at Heidelberg is complicated by the fact that it has to be supported by the tiny state of North-Baden (the U. S. part of Baden, being the northernmost quarter of the former state of Baden); this small state contains also the Heidelberg Observatory which is also state supported. A merger of the two institutions would seem indicated.

It would appear that the simplest function which the Rechen-Institut could resume is the continuation of the *Astronomischer Jahresbericht.* It would be a loss to astronomy if this useful series were permanently interrupted. Next in order might be the *Jahrbuch;* while the resumption of the other activities might be more remote, although Miss Nowacki, who did most of the editorial work on the *A. N.,* is at Heidelberg.

Professor G. Stracke, one of the key figures at the Rechen-Institut and editor of *Kleine Planeten,* died in August, 1943. An obituary, containing a review of his work and a complete list of his publications, was published by A. Kahrstedt.[1] In addition to Stracke's great merits in organizing the service that kept track of the asteroids, his recent work on Eros deserves to be mentioned. Unfortunately the wider program, which included the revision of some of the principal astronomical constants, was unfinished at his death. E. Rabe, now at Heidelberg, has taken over this program.

III Observatories

Heidelberg. The institute is undamaged and its staff has mostly returned. In particular, the valuable plate collection, obtained with the Bruce telescope, is intact and under K. Reinmuth's supervision. It is to be hoped that the positional work on minor planets, a subject cared for by very few observatories at present, will be resumed before long. During the war the director, H. Vogt, published a useful book "Aufbau und Entwicklung der Sterne" (Leipzig, 1943), and finished writing another book on extragalactic nebulae.

Munich. The Munich Observatory suffered severe damage. Ten bombs and a fighter aircraft dropped in the observatory yard. The house of the director (W. Rabe) and that of the assistant (P. Labitzke) were both partly demolished. The 11-inch refractor is intact, although the dome has sustained some damage and cannot be turned. The Repsold meridian circle was thrown out of its mounting onto the floor and

one of the circles (the one without the divisions) was bent. Rabe published 5700 double-star measures in 1939[2] and has since obtained several thousand more. He has obtained 14,600 measures since 1934; over 9,400 measures of 670 systems are still unpublished, some of them going back to 1929. The library building has been destroyed but 80 per cent of the books were saved. P. Labitzke, formerly of Königsberg, is now on the observatory staff.

Bonn. The Bonn Observatory was damaged but the library was saved. Kohlschütter had left Bonn for Thüringen (Eichsfeld) in front of the Allied invasion, with his computers and the files of the new *A. G.* catalog. They have later returned to Bonn, but O. Wachtl died in action with the Luftwaffe, March, 1942.

Göttingen. The director, O. Heckmann, left Göttingen for Bergedorf early in 1941 and was succeeded by P. ten Bruggencate. During the years 1941 to 1943 K. O. Kiepenheuer's Fraunhofer Institute was located there and the construction of a modern solar institute was begun on the Hainberg, a hill just outside the town. The Fraunhofer Institute was moved away to Freiburg in the Black Forest during the fall of 1943, but the solar institute was retained for Göttingen and completed by the end of 1944. The damage done to the institute, as well as to the older observatory in the city, is negligible. In addition to the director, W. Strohmeier, formerly of Potsdam and the Afrika Korps, works at Göttingen and also, as guest, E. Schoenberg, formerly director of the Breslau Observatory. W. Becker, formerly of Babelsberg and Vienna, stayed in Göttingen temporarily but left for Bergedorf in September, 1945.

Potsdam and Babelsberg. Both the observatories are just outside the city limits of greater Berlin and are therefore in the Russian zone of Germany. Kienle, von Klüber, Hassenstein, Münch, and H. Müller remained at Potsdam. The Einstein tower is being used by Kienle, although it has been damaged. At Babelsberg Guthnick and Brill remained behind while several astronomers went west, mostly to the Hamburg area. The damage to both observatories has been unimportant but it is reasonable to expect that some of the equipment will be used by the Russians for reparations. It should not be forgotten that the Pulkova Observatory was utterly destroyed and the Simeis Observatory dismantled by the retreating Wehrmacht in 1943 and shipped to Potsdam (without Kienle's approval), where it arrived in very poor condition.

No word has been received from H. Schneller, who was last reported visiting C. Hoffmeister at Sonneberg in Thüringen. The astrophysicist, W. Grotrian, was last reported[3] at Köthen, where he was commanding a battalion that saw heavy action against the Russian army near the Elbe River, south of Magdeburg. R. Müller now lives near Hamburg; E. von der Pahlen has gone to Switzerland, L. Biermann is at Bergedorf and may join the staff there; while Miss M. Güssow is now at

Heidelberg. K. Walter had in the fall of 1941 placed himself in charge of the Polish observatories and in 1944 had been the chief of a computational bureau in Poland under Alfred Rosenberg's "Ost" (East) organization; in this bureau labor from concentration camps was used. Walter is now in western Germany.

Breslau. The observatory was intact when its director, E. Schoenberg, left the city on January 23, 1945. The stock of undistributed publications was left behind. The result of subsequent operations was unkown to him.

Leipzig. The observatory in the city was largely destroyed in December, 1943, and a new station outside the town was built. To this station the director, J. Hopmann, moved the Repsold meridian circle which he had taken from the principal Belgian observatory, at Uccle.[4] Hopmann is now in western Germany and may reportedly join the Bonn Observatory staff.

Hamburg-Bergedorf. This is perhaps the principal observatory of Germany today. O. Heckmann, a man of great ability, is the director; the other staff members are Larink, Wachmann, Wurm, Cox, W. Becker, Biermann, Vick, Dieckvoss (PW in U. S.), Fricke, Thiessen, and Reis.

In the neighborhood of Hamburg live Unsöld (at Kiel); Przybyllock, formerly director of the Königsberg Observatory (now living at Lübeck), and Dick (Büsum). Other astronomers in western Germany are P. Wellmann (Betzdorf on the Sieg) and W. Strobel (Stade on the Elbe).

Two enterprises of the Hamburg Observatory are of especial interest abroad; the Bergedorf Spectral Durchmusterung, and the repetition of the *A. G.* catalogue. The situation in September, 1945, was as follows:

A. *Spektral Durchmusterung.* Volume 3 (+30° zone): the manuscript was ready in 1943 and was sent to Stuttgart for printing. The paper for this edition was burned; it was replaced but its final fate is unknown. Volume 4 (+15° zone): the manuscript is ready with two exceptions, (1) a check on the coordinates which was to be made by the Kapteyn Laboratory at Groningen; (2) the Groningen magnitudes for the standard stars, based on Harvard plates, had not been received. Volume 5 (0° zone): the same condition as Volume 4 except for seven fields for which no Groningen magnitudes have been received (*i.e.,* for no stars at all). These fields are SA 96, 98, 99, 100, 108, 110, and 114. The only magnitudes available are rough values determined at Bergedorf from the spectral plates. (Professor Bok writes that some of the standard plates taken at Harvard had not yet been sent to Groningen while others had not yet been taken. The program at Harvard had been interrupted by the war.)

B. *The* A. G. *Repetition.* Originally the German program called for a division of the work between Bergedorf, Bonn, and Berlin (Rechen-

Institut), with the first two observatories making the observations and Berlin the reductions. Early during the war it was decided that Berlin would finish the reductions of the comparison stars only, which they did[5] while Bergedorf and Bonn would reduce and publish their own observations. In addition Courvoisier was to publish separately his catalog of red stars, double stars, and other objects not suitable for photographic observation. This catalog was also published.[6]

The Bergedorf zone extends from the north pole to $+20°$, the Bonn zone from $+20°$ to $-5°$. The observations have all been made and the first part, $+50°$ to $+60°$, is being typed for reproduction. The next zone will be $+60°$ to $+70°$; thereafter $+80°$ to $+90°$. These three zones have been completely reduced. The remaining zones in the $+20°$ to $+90°$ belt are "in revision."

The finished catalogue will give the following columns: 1. Star number, a newly assigned number, not the original *A. G.* number; 2. Photographic magnitude, newly determined; 3. R. A. for 1950, given to 0.01 sec.; 4 and 5. The precession and secular variation in R. A.; 6. Declination for 1950, given to 0".1; 7 and 8. Precession and secular variation in declination; 9. Epoch; 10. *B. D.* number.

It will be disappointing to some astronomers that proper motions have not been derived. This shows an interesting and perhaps typical difference from the views governing the large program at Yale. The U. S. astronomers decided that proper motions based on two epochs would be better than no proper motions; while the Germans discarded this policy since it would not have used 100 per cent of the existing observations. They hoped to return to the proper motions separately.

C. An interesting investigation on the *general magnetic field of the sun* is being carried out by G. Thiessen. The method is different from that used at Mount Wilson in that a rotating $\lambda/2$ plate is being used and a Fabry-Perot interferometer that produces a system of dark rings on a bright background which is then observed visually. The dark rings are caused by high orders of the Fraunhofer line used in the investigation (Fe 5250 and 6173 A). The rotating $\lambda/2$ plate causes the rings to pulsate, owing to minute changes of wave length, and the amplitude of the pulsation is a measure of the general magnetic field. provisional determination of the field strength is 53 ± 12 gauss.

Of interest also is an investigation by K. Wurm on the determination of the magnetic field observed from the spiral motions in comet tails. A field strength of 10^{-6} gauss is found at one astronomical unit from the sun, consistent with the strength of the general magnetic field found on the solar surface.

Finally it may be recorded that Heckmann's high-precision work on the color-magnitude diagrams of galactic clusters was continued. In addition to the earlier work on the Praesepe and the Pleiades, now the Hyades have been added. The Hyades diagram is very similar to that

of Praesepe.

The equipment at Bergedorf is undamaged although some 200 incendiaries fell on the grounds. At the close of the war the 1-meter mirror (f/3) happened to be at Zeiss, Jena, for realuminizing and has not yet been recovered. The rest of the instrument is at Bergedorf.

Mussolini's Observatory. The Führer had announced with much fanfare that he was going to present the largest observatory in Europe to his friend, the Duce. Zeiss was going to produce it. Actually what happened is this:

The domes were complete in 1941 and were sent to Italy during the winter 1941-42. Professor Abetti of Florence was to be in charge of the institution. The domes were partially mounted in 1942. But BHF[7] (at that time Plendl) got them back to Jena, Germany, about December, 1943. The instruments themselves were never sent to Italy. They were ready early in 1944, except for the 1.5-meter Schmidt mirror. The mounting for this instrument had been started. The following instruments were ready:

1. Universal passage instrument.
2. Visual refractor, 60 cm aperture, 1100 cm focal length. (A few finishing touches were still to be made.)
3. Blink comparator.
4. Zeiss photoelectric photometer.
5. An astrograph.
6. Auxiliary equipment.

The plans had been made by Professor Bianchi, an Italian astronomer, who used conservative designs. The absence of modern solar equipment was regretted by some of his colleagues.

The Fraunhofer Institute got the dome for No. 2, and also items Nos. 3 and 4. All other instruments and domes remained in Jena.

The German Reich had paid Zeiss for the domes already shipped to Italy but not for the items still at Jena. BHF wanted to pay for the large refractor, but the arrival of the Americans intervened. The refractor was to be for the Fraunhofer Institute (Schauinsland).

The Potsdam Observatory was to get the astrograph (No. 5), and the Hamburg Observatory the 1.5-meter Schmidt mirror. But the Fraunhofer Institute got the best part—the part that was ready.

It has since been reported that the Schmidt telescope is being finished at Jena for the reconstructed Pulkova Observatory.

IVa The Fraunhofer Institute

German solar research was coordinated by K. O. Kiepenheuer, director of the Fraunhofer Institute. It was part of a larger organization, the Reichsstelle für Hochfrequenzforschung e.V., whose chief was first Plendl and, after the fall of 1943, Esau. This shows that German solar work was carried out for the purpose of forecasting ionospheric con-

ditions. Kiepenheuer's claims in this connection were not fulfilled during the war (although it is possible that continued research would have justified them). But astronomy has greatly gained by the erection of six solar observatories, four of which have survived the war. It is doubtful whether in time of peace such an ambitious program could have been carried out. Incidentally, this considerable expenditure was made at the cost of the German war effort.

It was Kiepenheuer's program to coordinate and foster solar research, not only in Germany and Austria, but also in occupied countries. The solar institutions of occupied lands were given protection from interference by the German military in exchange for collaboration. It is not surprising that such efforts were suspected in spite of the tact which Kiepenheuer employed. For instance, Kiepenheuer's attemepts to bring the Belgrade observatory within his organization were largely frustrated by the removal of coelostat mountings by the Yugoslav underground. The spectroheliograph[8] was thereupon requisitioned and used, together with German equipment, to build a solar observatory near Syracuse, Sicily.

As a result the principal stations contributing solar data to the Fraunhofer Institute were the station in Sicily, four new Alpine observatories, described below, and the Potsdam Observatory. The solar station at Göttingen was also built under this program but was not completed until late 1944 (see page 266). Research work at Göttingen did not start until September, 1945, when the university was reopened by the British Military Government.

Syracuse, Sicily. Solar observations started in the spring of 1942. The first instrument was a Steinheil refractor $f = 100$ cm, with which images 8 cm in diameter were taken in white light. The relative sunspot numbers, R, were determined as well as the spot coordinates, and the results were relayed by radio to the "Zentralstelle für Funkberatung," a sister institution under the directorship of Dr. Dieminger, dealing specifically with ionosphere research and radio forecasting. During the summer of 1942 the Belgrade spectroheliograph with Zeiss coelostats was added, and complete work was begun in the winter 1942-43. Spectroheliograms were taken in $H\alpha$ and CaII (K3 line); the images were 4 cm in diameter.

With the Allied conquest of Sicily, late in 1943, the equipment failed to get evacuated to Germany, because the director of the station, P. Wellmann, was absent during that time. The equipment was left at Catania airport in boxes marked "E-Stelle Rechlin" (the address) and "Askania Werke" (the manufacturer), but no name was added. The spectrograph contained a plane Rowland grating.

The Alpine Observatories. These observatories were constructed primarily for the observation of the corona, with a Lyot-type coronagraph. Dr. Lyot himself had forstalled weak German attempts of using

the Pic du Midi Observatory in the Pyrenees. Four stations were built, one in the Black Forest above Freiburg, two in the Bavarian Alps, and one in the Austrian Alps. Their equipment and staff at the close of the war were as follows:

1. *Schauinsland,* above Freiburg i. Br., 1295 meters high. Equipment:

(a) A tower telescope, with grating-type spectroheliograph; main objective 20 cm aperture, 5 meter focal length; grating by Zeiss, Jena. (b) A second tower telescope, for continuous observation of magnetic-field strengths in sunspots, using an interferometer. (c) A twin refractor for general survey of the solar disc and photography of prominences through an interference filter; dimensions: apertures 15 and 11 cm, focal lengths 2.25 and 1.65 meters. (d) A photoelectric photometer and other auxiliary equipment. (e) An unfinished coronagraph of new design (a rotating objective with synchronous scanning device).

Staff: Dr. Kiepenheuer, astronomer and director, Pfalzgraf (photographer and chemist), Deichmann (mechanic), Bünemann and Giesekus (physics students).

2. *Wendelstein,* near Brannenburg on the Inn, south of Rosenheim, Bavaria, 1840 meters high. Equipment:

(a) A tower telescope with spectroheliograph containing a Rowland grating (from the second Physics Institute, Göttingen). The main objective is 20 cm aperture, 5 meters focal length. (b) A coronagraph, 11 cm aperture, 1.65 meters focal length, with a refractor, having the same dimensions, mounted parallel. The coronagraph has an interference filter, a prominence spectrograph and a scattered-light photometer. (c) A photoelectric photometer. (d) A blink comparator, and other small articles.

Staff: Dr. Haffner, astronomer; a physics student (Mr. Jäger) and his wife, who is a technical assistant.

3. *Zugspitze,* near Garmisch-Partenkirchen, 3000 meters high. Equipment:

A coronagraph, 11 cm aperture, 1.65 meters focal length, with a refractor of the same dimensions mounted parallel.

Staff: Dr. Bruzek, astronomer.

4. *Kanzelhöhe,* near Villach, west of Klagenfurt, Austria, 1500 meters high. Equipment:

(a) A tower telescope with spectroheliograph, Rowland concave grating, $R = 3$ meters. Primary objective 15 cm aperture, 4 meters focus. (b) A coronagraph with parallel refractor, as on Wendelstein and Zugspitze. (c) A photoelectric photometer.

In preparation was a coronagraph, 20 cm aperture, 3 meters focus, to be put farther northeast on the Kanzel, 1900 meters high. The dome was delivered by Zeiss and the rest is nearly ready, at Zeiss, Jena.

Staff: Ing. Marius, a physicist, and Miss Gerda Conrad, technical assistant.

The Zugspitze station was found damaged by soldiers, although the coronagraph objective may have been rescued when the astronomer left the station. The other three observatories are completely intact.

Kiepenheuer moved the Fraunhofer Institute from Göttingen to Freiburg in the fall of 1943. At first he had quarters in the mathematical institute of Freiburg University but later acquired one floor of the small castle at Ebnet, three miles east of Freiburg and some ten miles from the mountain station. The university suffered heavy damage

during an aerial attack in November, 1944, but the library and equipment of the institute were largely saved.

Ebnet and Schauinsland are in the French zone of Germany and the astronomical work is continuing on a limited scale. The food problem is quite serious, as in other parts of Europe. The observing conditions at the mountain station are favorable, though surpassed by those at Wendelstein. The latter observatory has one of the finest locations in the world. The view of the chain of towering Alps, from Zugspitze, 100 km to the west over the high Tyrolean Alps to the Hohe Tauern, 100 km to the southeast, is unexcelled. The observatory is above the tree line and the sky is usually free from dust and fibers from vegetation.

The Kanzel Observatory is built on a mountain chain bordering the Drau valley from the north, running from Klagenfurt to Villach. On the opposite or southern side of the valley one sees a wild mountain range in which Yugoslav partisans held out all during the war, with Allied aircraft dropping supplies by parachute. The climate is much milder than that at Wendelstein, but the air contains quantities of fibers from the dry moss which covers the trees. As a result the site is not suitable for coronal observations except during a few days each year. The university of Graz has taken over the observatory and Professor Fell, of Graz, is now in charge.[9] Professor Fell and Miss Conrad have indicated their desire to continue the solar observations, and to try to locate a better site for the coronagraph, elsewhere in the Austrian Alps.

IVb Scientific Results

The Fraunhofer Institute issued a number of publications, which are abstracted below. The abstracts are translations of the original German summaries. In addition a colloquium was held on the Wendelstein (January 10-13, 1944) in which a number of papers were presented bearing on solar research and solar-terrestrial relationships. The titles of these papers are also listed below.

Report (Forschungsbericht) No. 1. Relations Between Solar Eruptions and Geomagnetic Disturbances. By H. Giesekus and K. O. Kiepenheuer, November 15, 1943.

A statistical discussion of observations extending over seven years (1935-41) shows it to be very improbable that chromospheric eruptions are the cause of geomagnetic disturbances or of magnetic storms. A weak correlation seems to exist but this shows only that both phenomena have a common cause, an "active area" on the sun.

FB No. 2. A Comparison Between the Limiting Frequencies at Syracuse with Geomagnetic and Solar Phenomena. By P. Wellmann, Deccember 21, 1943.

There are three components to the mean daily limiting frequencies of the F2 reflection, observed at Syracuse between September 1, 1942, and May 31, 1943: 1) a basic curve with the seasonal variation; 2) sudden minima lasting a few days, caused by corpuscles; 3) slow variations, lasting some weeks, correlated

with the strength and frequency of disturbance centers on the sun. The *second* class has the following properties: they start one day after the beginning of the magnetic storm, their maximum comes ¾ day later; they fall off more slowly than the magnetic disturbance and last about two days longer. The *third* class is studied by introduction of a number indicating the *faculae activity* on the disc. At the maximum of this activity (during the interval of the observations) the limiting frequency rose about 1 MHz (1 megacycle). It is probable that the UV activity of the hot faculae are the controlling factor.

The limiting frequencies obtained at Rechlin confirm the Syracuse results but they are less useful because of the frequent occurrence of short-period (corpuscular) disturbances.

Colloquium on Solar Physics, Wendelstein, January 10-13, 1944. Program:

Kiepenheuer: Problems of the Solar-physics Group.
Haffner: Corona observations on the Wendelstein and the Zugspitze, 1943. (FB No. 3)
Kiepenheuer: Deviations from thermal equilibrium in the outer layers of the sun. (FB No. 4)
Kienle: The continuous spectrum of the sun between 3000-4500 A.
Wellmann: A comparison between . . . etc. (FB No. 2)
Bartels: Proof of the 27-day repetition in geomagnetic disturbances through 14 solar rotations.
Heckmann: Results with a spectroheliograph.
Dieminger: A meridian cross section through the ionosphere.
Biermann: The theory of the magnetic fields on the sun.
Wurm: Magnetic field in tails of comets.
Dieminger: Galactic noise (between 2-20 meters).
Wille: Photoelectric photometry of the night sky.
Ehmert: Cosmic rays and solar magnetic field.

FB No. 3. Results from observations of the corona on the Wendelstein and the Zugspitze. By H. Haffner, February 20, 1944.

Two identical coronagraphs of the Lyot type ($A = 11$ cm; $F = 165$ cm) were mounted on the Wendelstein and the Zugspitze during the spring of 1943. This article discusses the observations made from May to November, 1943, in the green coronal line λ 5303, and particularly the spatial distribution of the monochromatic corona and its relation to geomagnetic variations.

A pronounced zonal distribution of the coronal material is found between latitudes $\pm 65°$. There is a difference between the zones with and zones without sun-spots (intensity, extension). The brightest parts of the corona are usually connected with large groups of spots of long duration, but exceptions do occur in which bright coronal rays are found without special photospheric features. If the coronal intensities are derived for all solar meridians (from observations of the limbs) and then each time collected into a 60° zone around the center of the apparent disc, these zone intensities show a parallelism with the variations of terrestrial magnetism (as found at Potsdam). Nineteen maxima of the magnetic field are present which in 15 cases coincide with coronal maxima; while of the 17 coronal maxima, 15 coincide with magnetic maxima. No quantitative interpretation is as yet possible.

FB No. 4. Deviations from thermal equilibrium in the outer layers of the sun. (Theory of faculae and the corona.) By K. O. Kiepenheuer, February 25, 1944.

The electrical conductivity of the solar atmosphere is computed depending on optical thickness, density, degree of ionization and magnetic field strength. Based on the computed conductivity the magnetic field near a sun-spot is computed, as well as its variation with time. Taking into account chromospheric turbulence one finds that the Joule heat developed by the induction currents is not negligible as a source of energy, and that it provides an explanation of the deviations from thermal equilibrium observed in faculae. The kinetic energies of the

charged particles in the induction current may exceed appreciably the value $kT_{\odot}$. One may expect local temperatures up to 10,000° or more, which however in the visual spectrum cause only slight increases in brightness.

The energy balance of the corona is discussed. The corona consists essentially of protons and electrons only. Free-free transitions produce about 10^5 erg/cm²sec., with a spectral distribution which for $\lambda < 1000$ A exceeds the photospheric intensity by several powers of 10. This high UV intensity may well be regarded as the source for the ionization of the F2 layer.

It is assumed that the corona is not supported by radiation pressure, but corresponds to a Boltzmann atmosphere with $T \sim 10^6$. Maintaining this temperature requires an emission of about 10^5 erg/cm²sec. This cannot take place in the UV nor as fast corpuscles because the chromosphere would show the signs of it.

The general magnetic field of the sun is quantitatively insufficient as an energy source. More promising is a stream of slow particles passing through the chromosphere and accelerated inside the corona. The lifetime of an H atom and the radiation pressure on it are estimated. It is found that small deviations from thermal equilibrium in the chromosphere suffice to cause accelerations of the H atoms by the required amount. *The energy source of the corona is therefore assumed to be the Lyman series emitted by the chromosphere* (taken over the *whole* solar surface).

It is pointed out that the absolute intensities of the coronal lines agree with the assumption that the coronal ions (Fe, Ca, Ni) are of meteoric origin. The concluding remarks concern solar-terrestrial relationships.

Properties of the ultra-violet radiation of the sun. By K. O. Kiepenheuer, February, 1944. (A short paper superceded by FB No. 5.)

FB No. 5. The Absolute Intensity and Other Properties of the Solar UV Radiation (λ 600-900 A) that Produces the Ionosphere. By K. O. Kiepenheuer, August 1, 1944.

An investigation is made of the production of charged particles in the ionosphere, as well as of their recombination. The purpose is to determine the absolute intensity of the UV radiation in the sun, and its variation.

The resulting estimates show an excess over black-body radiation ($T_{\odot} = 5780°$) by a factor roughly 10^5 for the E layer (λ 661-744 A) and the F_1 layer ($\lambda < 661$ A); and an excess roughly 10^3 for the F_2 layer (λ 744-910 A). The analysis of the daily F_1 and F_2 limit frequencies obtained in 1941-43 gives a *linear* relationship between sun-spot number, R, and intensity of the ionizing radiation. More precisely, *during a sun-spot cycle (between $R = 0$ and $R = 150$) the strength of the E layer changes in the ratio 1:2.4 of the F_1 in the ratio 1:2.6, and the F_2 as 1:12.* The variation of the F_1 layer, and probably also of the F_2 layer, has two components: a) a slowly changing component which follows the sun-spot numbers R with a delay of a few solar rotations; presumably it depends on the whole solar disc; and b) a rapidly changing component, following the numbers R without phase shift; presumably it is due to limited disturbed areas on the sun.

The sun is therefore strongly variable in the UV. Because of the strong absorption such UV radiation would experience in the solar atmosphere, the source of it must be in the outer parts of the chromosphere or the inner parts of the corona.

It is shown that component a) of the F_1 layer may be interpreted as due to the free-free and free-bound transitions in the inner corona, the latter being mainly composed of free electrons and protons with $T > 10^5$ degrees. Not only the absolute strength but also the correlation with sun-spot activity point to this conclusion.

An estimate is made of the strength of the Lyman continuum radiated by prominences and faculae. It is found that the granules of the faculae are strong UV sources; they are assumed to be responsible for the rapidly varying components b) of the F_2 and F_1 layers. This conclusion is consistent with the absolute strength of components b) and their close correlation with R.

The remaining intensities of the E, F_1, and F_2 layers during the sun-spot minimum ($R = 0$) are assumed to be due to the many small prominences which

form the top of the outer chromosphere; the frequency of these seems to be independent of the sun-spot cycle.

Mitteilungen des Fraunhofer-Institutes.

No. 1. Minimum of the Relative Sunspot Number, by E. Walker, September 28, 1944.
No. 2. The Evolution of Sunspots, by E. Walker, October 3, 1944.
No. 3. The Visibility of Sunspots and Sunspot Goups, by A. Bruzek, November 1, 1944.

From these abstracts it is clear that the scientific work carried out was on a high level. Particularly papers No. 4 and No. 5 are of great interest to astrophysicists. It is hoped that soon more extensive account of this work can be given. Most of the papers presented during the Wendelstein conference (see above) have been printed in abstract form only. These abstracts, as all other papers issued by the Fraunhofer Institute, are on file at the Yerkes Observatory.

The great store of coronal observations collected by the Fraunhofer Institute, especially at the Wendelstein, will be of great value in further studies of solar-terrestrial relationships. Dr. Kiepenheuer is making available microfilm copies of his records. It is to be hoped that these difficult observations which had run for years continuously will be permitted to be resumed, particularly since Dr. Lyot's observations on the Pic du Midi are not yet continuous.

Attention is further drawn to some remarkable unfinished projects. Kiepenheuer, in collaboration with Regener, made a strenuous effort to measure directly the far ultra-violet intensity of the sun. It was proposed that recording equipment be shot up to very high altitude and the following three quantities be measured: a) the intensity of the Lα in the sun; b) the intensity of the continuous spectrum on each side of 1000 Å; c) the intensity of cosmic rays at the top of the atmosphere.

The first method adopted for reaching very high altitudes was by use of the V2 rocket. The first experiments called for attaining the altitude of 60 km; the figure was later to be increased to 140 km. The German services had promised these men a V2 in which the warhead would be replaced by a cylinder one meter high and 80 cm in diameter, in which they could put any measuring equipment they chose.

A LiF (UV) spectrograph was constructed with a novel type of recorder. Because of the possible weakness of the solar far UV compared to the intensity in the normal photographic region (for a black body of 6000° the ratio at λ 800 A would be about 10^6), the problem of scattered light in the spectrograph might be extremely severe if photographic plates were used. For this reason the photographic plate was replaced by a set of halegonid crystals as devised by the physicist Pohl and his co-workers at Göttingen. Such crystals discolor when exposed to UV radiations of a narrow specified wave-length band and the change of color is a measure of the total radiation received in that band. Kiepenheuer used this device by putting crystals of the proper wave-

length sensitivity along the focal curve of the spectrograph. In this ingenious way the problem of scattered light was completely solved. The sensitivity of the device was increased by a special procedure enabling the measurement of intensities too weak to give noticeable color effects. Exposed crystals were afterwards irradiated with red light and the change of internal resistance was measured. This procedure measured the number of free Na ions in the crystal caused by the original UV rays.

It was the plan to have the cylinder with the spectrograph and the cosmic-ray equipment ejected from the V2 at maximum altitude. During the ejection, the cylinder would receive a slight spin so that it would have a corkscrew motion going down; it would be parachute supported. The spectrograph was so constructed as to admit light from a 90° vertical arc (from the zenith to the horizon if properly oriented) but with a narrow beam at right angles. With the cylinder rotating the sun would enter the spectrograph a definite fraction of the time regardless of the speed of rotation.

The cylinder, with its equipment, was ready in July, 1944, but by then Regener and Kiepenheuer did not succeed in getting their V2. Their next attempt was to insert Pohl-type crystals without a spectrograph, simply as recorders of UV radiation, first in 21 cm shells used in railroad guns of very high muzzle velocity (about 1400 m. sec^{-1}) and later in small rockets. In this manner it was hoped that at least medium altitudes of 60 to 80 km could be reached. The final and simplest device was a rocket which, together with its launching tube, weighed only 5 kg and would be carried by means of a cluster of balloons to somewhat over 30 km elevation before being fired. Because of the rapidly changing conditions in Germany during 1944 and 1945 no final results were achieved before the end of the war. The only complete test was one obtained in the very beginning of the program, in 1939, when a cluster of six pilot balloons carried a series of Pohl crystals to 31 km elevation and recorded radiation in the gap near 2000 A, between the oxygen and ozone absorption. No calibrating device was then available, however, so that no numerical data can be given.*

V General

1. This report would be unbalanced without a reference to the darker side of the picture. In the first place there is the aggressive Nazi activity on the part of some astronomers. The majority of the astronomers are not in this class. In fact, among many there was a latent feeling of dissatisfaction with Nazi theories, though only a few scientists expressed such views openly. Among these are von Laue in physics, and Heckmann in astronomy. Nearly all astronomers who were not party members before the war became members during the war. I

*A few additional data are found in *V. J.*, **75**, 103, 1940.

know of only one notable exception. This will be disappointing to many of us in view of the violent anti-intellectual stand the Nazi party had taken up to about 1941; when, *e.g.*, theoretical physicists were often classed with "Jews and Marxists."

Many of the younger astronomers participated actively in one of the German services, but in 1943 most of them were released as part of the general program to bolster science. This step was taken, as a result of the initiative of Esau and particularly Osenberg, after the comparative weakness of Germany's scientific preparation had been demonstrated. The surprising thing is that the recalled astronomers, as their older colleagues, and their colleagues in some other fields, did mostly work of their own choosing, often with government support.

2. The attitude of some astronomers is demonstrated by their own publications. *E.g.*, the German director of the Graz Observatory, K. Stumpff (formerly of Breslau) writes in his report for 1942:[10]

"The nucleus of the new observatory at Graz will be made up out of several fairly large instruments of the Belgrade Observatory which, according to the Dictate of Versailles, the Reich had to deliver to the former Yugoslav State, and which now had to be returned." He continues in his next year report:[11] "The Belgrade instruments assigned to the Graz Observatory could not yet be moved in 1943. As a result of two trips I made to Belgrade I got assurances that they will be shipped by the summer of 1944." (See, however, footnote 8.)

Other removals of astronomical equipment from Allied territory are the two important telescopes from Uccle, Belgium (see p. 267) and the dismanteling of the Simeis Observatory (see p. 266). Uccle and Belgrade have one point in common: both had obtained reparation equipment after the first world war.

3. One of the symptoms of intellectual deterioration in Nazi Germany was the wide-spread use of pseudo-scientific theories. Not only was astrology widely practiced, even in Hitler's headquarters, but the theory of the world ice was popular, as well as the theory that the world was a hollow shell, with the human race living on the inside (Hohlweltheorie). The following illustrations may suffice:

a. Dr. W. Führer, a graduate of Kiel (Rosenberg, Unsöld) and later an associate of the physicist Lenard at Munich, was "Referent für Mathematik, Astronomie und Physik" under Ministerialdirektor Mentzel, 1940-1943. In this important capacity he had a large share in making Nazi appointments to German universities. (*e.g., the successor to Sommerfeld!*). In 1943 he reportedly became official astrologer for Himmler and Hitler, at the Führer's headquarters.

b. Certain German naval circles believed in the Hohlweltheorie. They considered it helpful to locate the British fleet, because the curvature of the Earth would not obstruct observation.

Visual rays were not suitable because of refraction; but infrared rays had less refraction. Accordingly a party of about ten men under the scientific leadership of Dr. Heinz Fischer, an infrared expert, was sent out from Berlin to the isle of Rügen to photograph the British fleet with infrared equipment at an upward angle of some 45°.

c. Other groups, including officers of flag rank, practiced or supported "Pendelforschung": a large map of the Atlantic was spread out horizontally, with a 1-inch toy battleship as test object. A pendulum, consisting of a cube of metal (about 1 cm^3) and a short string, was swung above the battleship. If the pendulum reacted it proved the presence of a true battleship at that location.

d. This intellectual regression is only part of the general anti-cultural movement that supported Nazism. Other symptoms are (a) the racial theories, (b) the sacrifice of conscience to the will of the race (as personified in the Führer), which often resulted in extreme cruelty.

e. Most scientists did not actively support the anti-intellectualism of the Nazis, and combatted the pseudo-scientific theories (though not always the racial theory). In this connection a book by R. Henseling, "Umstrittenes Weltbild," Leipzig, 1939, may be quoted. In fairness it should be stated that the milder forms of pseudo-science are not confined to Germany.

VI German Astronomical Publications during the War

The lists of publications given below should be essentially complete for the following observatories: Heidelberg, Göttingen, Munich, Hamburg-Bergedorf, the Rechen-Institut, and the Fraunhofer Institute. Information received on publications by other observatories was less direct, and only the principal issues have been listed. Complete information up to the end of 1943 may be obtained from the year reports of observatories, listed below.

Articles in common periodicals, as *Zs. f. Ap., A. N., B. Z.*, are usually not listed separately since these periodicals are listed themselves. Only for observatories where a complete list was at hand have all titles been retained.

A copy was secured of all publications issued by observatories visited; they are on file at the Yerkes Observatory and are available for reference and reproduction to interested astronomers. Publications for which no copy is at hand are listed with an asterisk.

Many of the publications have already been circulated in the U. S. thanks to the Committee for the Distribution of Astronomical Literature (Chairman, Dr. B. J. Bok). The Bulletins issued by C. D. A. L. further contain useful abstracts. Titles given below for which such

abstracts have been issued are followed by the C. D. A. L. Bulletin number in parentheses.

One of the tragedies of this war has been the burning of books and magazines. The great publishing centers of Leipzig, Berlin, Braunschweig, and Dresden, as well as some lesser ones, sustained heavy fire damage in air raids. Many complete editions as well as the undistributed stock of other editions have perished. The problem of completing our libraries deserves careful study; the modern litho-process is both adequate and inexpensive.

1. Books. In addition to several popular books (reviewed in *Vierteljahrsschrift*) the following more important books have been issued:

*H. Happel, Das Dreikörperproblem, Leipzig, 1941.—According to the review by Prof. A. Klose of Berlin (*V. J.*, **77**, 254, 1942) an important book which includes the newer methods and results.

*M. Waldmeier, Ergebnisse und Probleme der Sonnenforschung (Probleme der Kosm. Physik, Bd. 22), Leipzig, 1941.—Review by ten Bruggencate, *V. J.*, **77**, 262, 1942. (14).

E. Kamke, Differentialgleichungen, Lösungsmethoden und Lösungen (2 vols.) Leipzig, 1942.—A very fine book.

*E. Zinner, Geschichte und Bibliographie der astronomischen Literatur in Deutschland zur Zeit der Renaissance, Leipzig, 1941.—Review by Willy Hartner, *V. J.*, **76**, 166, 1941.

*W. Becker, Sterne und Sternsysteme, Leipzig, 1942. (14).

Otto Heckmann, Theorien der Kosmologie, Springer, 1942. (14).—A penetrating and spirited review by von Weizsäcker, *V. J.*, **78**, 208, 1943.

W. Heisenberg, Kosmische Strahlung, Springer, 1943.

H. Vogt, Aufbau und Entwicklung der Sterne, Leipzig, 1943.—A clear, compact, and useful small book.

In press at the end of the war:

*Newcomb-Engelmann, Eighth Edition (edited at the Potsdam Observatory).

*H. Vogt, Die aussergalaktische Nebel.

(*)H. G. Küssner, Principia Physica (Herausgegeben von der Deutschen Akademie der Luftfahrtforschung).—(Professor Küssner was attached to the Aerodynamische Versuchsanstalt, Göttingen).—This book was highly praised by Sommerfeld, but because it appeared to contain a great deal of cosmological speculation the writer requested Professor Pascual Jordan to review it. Jordan's opinion was quite critical. Since the book plates are in Berlin and only a final proof copy exists at Göttingen the future of this book is uncertain. An eight-page abstract, written by Küssner, was secured and is on file together with Jordan's review.

In addition, a number of important *mathematical tables* were printed. At least two of these have been re-issued in the U. S. under the auspices of the Alien Property Custodian: "Seven-place Values of Trigonometric Functions for every 0°.001" and "Eight-place Table of Trigonometric Functions for every Second of the Quadrant." Both are by Prof. J. Peters.

2. *Vierteljahrsschrift der A. G.* The following volumes have appeared: **75**, 1940; **76**, 1941; **77**, 1942; **78**, 1943; **79**, 1944. Vol. 79 consists of a single issue; the other volumes of four "Hefte," with the second and third, each time, combined into one issue.

This publication gives a great deal of information on the activities of German observatories and their personnel during the war. Some of the more important items are listed below.

a. *Year Reports* of German and Austrian observatories.

Year 1939	Vol. 75, 42-172, 1940
1940	76, 52-161, 1941
1941	77, 104-230, 1942
1942	78, 101-198, 1943
1943	79, 10- 84, 1944

Included also are the reports for Arcetri and Zurich (up to the end) and Vatican and Stockholm (up to Vol. 78).

The report of K. Walter on his Polish observatories ("Sternwarten des Generalgouvernements") deserves special mention (Vol. 79, 42-56, 1944). Dr. Wilk's death in February, 1940, is recorded, but not its cause (starvation, according to a report received). The gradual elimination of Professor Banachiewicz is only casually mentioned, but not his imprisonment after the fall of Poland, or the scientific isolation imposed on Polish scientists after 1942 by preventing them to write to scientists outside the Generalgouvernement. Neither is a description given of the "Institut für Deutsche Ostarbeit in Krakau" (*cf.* p. 267). Incidentally, Drs. Biermann and Wellmann received the Kopernikus Preis of this Institute in 1943 (*V. J.*, **79**, 14, 1944).

Reference is also made to Hellerich's reports on the Strasbourg Observatory; later he became a prisoner of the French.

b. Discoveries of *asteroids* are listed by:

A. Kahrstedt, Zusammenstellung der Planetenentdeckungen im Jahre:

Year 1939	Vol. 75, 28-39, 1940
1940	76, 40-47, 1941
1941	77, 87-98, 1942
1942	78, 88-97, 1943
1943	79, 85-92, 1944

c. *Comets* are reviewed by:

H. Müller, Zusammenstellung der Kometenerscheinungen:

Year 1938	Vol. 75, 23-27, 1940
1939	76, 23-39, 1941
1940	77, 76-86, 1942

d. A number of important *original contributions* appeared in the *V. J.*

P. ten Bruggencate, Die Häufigkeit des Wasserstoffs in Sternatmosphären; **75**, 203-252, 1940.

Symposium on Solar Physics, Göttingen, Oct. 3-4, 1941: P. ten Bruggencate, Wasserstoffhäufigkeit und Turbulenz in der Sonnenatmosphäre; **76**, 172-184 (9).

H. Siedentopf, Sonnengranulation und zellulare Konvektion; **76**, 185-193 (9).

L. Biermann, Der gegenwärtige Stand der Theorie konvektiver Sonnenmodelle; **76**, 194-200 (9).

K. O. Kiepenheuer, Die Ausstrahlung der Sonne im fernen Ultraviolet; **76**, 201-206 (9).

K. Wurm, Die Natur der Kometen; **78**, 18-87, 1943. Errata p. 260.

A. Unsöld, Über die Theorie der Druckverbreiterung und -verschiebung von Spektrallinien; **78**, 213-259, 1943.

e. Obituaries:

Anders Donner	(1854-1938)	by E. Strömgren	**75**, 2, 1940
Gustav Eberhard	(1867-1940)	by H. Ludendorff	**75**, 174, 1940
Paul V. Neugebauer	(1878-1940)	by G. Stracke	**75**, 185, 1940
Hans Ludendorff	(1873-1941)	by P. Guthnick	**77**, 2, 1942
Jean Peters	(1869-1941)	by O. Kohl	**77**, 16, 1942
Karl Boda	(1889-1942)	by W. Hartner	**77**, 232, 1942
Hermann Kobold	(1858-1942)	by M. Ebell	**77**, 241, 1942
Gustav Stracke	(1887-1943)	by A. Kahrstedt	**79**, 1, 1944

Conspicuously missing among the obituaries is that of Professor R. Emden, the great pioneer of theoretical astrophysics and founder of the *Zeitschrift für Astrophysik*. He died October 8, 1940, at Zurich, Switzerland. Other deceased astronomers:

Dr. B. Jung (Breslau), H. von Hoff (Göttingen), Prof. A. von Brunn (Potsdam), in 1940; Prof. Ph. Fauth (Grünewald), Prof. M. Maggini (Teramo), Prof. E. Bianchi (Milan), in 1941; Dr. F. Schembor (Vienna), E. J. Meyer (Wolfersdorf), Dr. O. Wachtl (Bonn), in 1942; Prof. J. Stobbe (Posen), Dr. H. Strebel (Munich), Prof. A. Galle (Potsdam), in 1943. Further Dr. Beilke (Göttingen and Potsdam) has been missing at Stalingrad (December, 1942).

(*) 3. *Zeitschrift für Astrophysik*. Microfilm copies were obtained in 1944 in Paris up to the end of Vol. 22 (end of 1943). Three issues of Vol. 23 have appeared in 1944, but no spare copies were found in western Germany. Many important articles have appeared in this magazine, among which we mention Unsöld's series on τ Scorpii; Biermann's work on convection and the composition of the sun; and von Weiszäcker's article on the origin of the solar system. Most of these articles have been listed and abstracted in *C. D. A. L. Bull.*, 2, 4, 7, 8, 9, 10, 14, 22. Some of the important ones have been reviewed in the *Astrophyical Journal*.[12]

(*) 4. *Astronomische Nachrichten*. The last volume is 274 (incomplete). For titles and abstracts see *C. D. A. L. Bull.*, 3, 4, 7, 8, 10, 14.

* *Beobachtungs Zirkulare der A. N.* continued to appear in 1944. Vol. 25 (1943) had 21 numbers, 124 pages.

* *Astronomische Abhandlungen.* The following numbers appeared: Vol. 10, Nos. 2, 3 (1940); 4-6 (1941); No. 7 and Vol. 11, No. 1 (1942); No. 2 (1943). For titles of Vol. 10, *cf. C. D. A. L. Bull.*, 14, p. 7.

5. *Rechen-Institut publications.* The fate of the principal publications, *Kleine Planeten, Berliner Astronomisches Jahrbuch,* and *Astronomisches Jahresbericht,* has been reviewed in section II. Dr. Heckmann of Bergedorf has made available a copy of each volume of *Kleine Planeten* and *Berliner Jahrbuch* that had appeared (1942, 43, 44 and 1943, 44, 45, respectively); while Dr. Kopff made available a partially complete copy of the 1946 *Jahrbuch* as well as the *Jahresbericht,* literature for 1941.

The following *Mitteilungen* have appeared, beginning with 1940:

Band 5, No.

6: E. Rabe, Die Bahn des Planeten 1 Ceres, *A. N.*, **270**, 82.
7: G. Stracke, Elemente und Numerierung von Kleinen Planeten, *A. N.*, **270**, 93.
8: A. Kahrstedt, Zusammenstellung der Planetenentdeckungen im Jahre, 1939, *V. J.*, **75**, 28.
9: W. Gliese, Bestimmung der Sonnenbewegung und der galaktischen Rotation, hergeleitet aus den Eigenbewegungen des FK3, *A. N.*, **270**, 127.
10: G. Miczaika, Die Sterne grosser Geschwindigkeit, *A. N.*, **270**, 249.
11: G. Hagemann, Die Radialgeschwindigkeiten der Sterne des FK3, *A. N.*, **271**, 1.
12: E. Rabe, Über die mittleren Bewegungen im Hecuba-Problem, *A. N.*, **271**, 92.
13: E. Rabe, Periodische Lösungen für die Bewegung eines Doppelplanetoiden, *A. N.*, **271**, 181.
14: G. Stracke, Elemente und Numerierung von Kleinen Planeten, *A. N.*, **271**, 186.
15: A. Kahrstedt, Zusammenstellung der Planetenentdeckungen im Jahre 1940, *V. J.*, **76**, 40.
16: G. Stracke, Über die Abnahme der Helligkeiten der Kleinen Planeten, *A. N.*, **271**, 280 (4).
17: G. Stracke, Die Eros-Bewegung von 1940-42 und die Eros-Ephemeride für 1942, *A. N.*, **272**, 27.
18: G. Stracke, Elemente und Numerierung von Kleinen Planeten, *A. N.*, **272**, 82.
19: W. Gliese, Die Untersuchung der Raumgeschwindigkeiten der FK3, *A. N.*, **272**, 97.
20: A. Kahrstedt, Zusammenstellung der Planetenentdeckungen im Jahre 1941, *V. J.*, **77**, 87.
21: A. Kopff, Die Genauigkeit des Katalogs der Anhaltsterne des AGK2, Abh. der Preuss. Akad. d. Wiss., 1942, No. 5.
22: W. Gliese, Abschätzungen des Kraftfeldes der galaktischen Rotation, *A. N.*, **272**, 201.
23: G. Stracke, Über die geometrische Gröse und die Masse der Kleinen Planeten, *A. N.*, **273**, 24 (14).
24: E. Rabe, Genäherte Theorie des Planeten 1 Ceres, *A. N.*, **273**, 24.
25: E. Rabe, Eine zweckmässige Methode zur Berechnung der allgemeinen Störungen der Planeten, *A. N.*, **273**, 209.

Band 6, No.

1: Elemente und Numerierung von Kleinen Planeten, *A. N.*, **273**, 283.

2: G. Stracke, Die Eros-Bewegung von 1942-45 und die Eros-Ephemeride für 1944-45, *A. N.*, **274**, 21.

Among the many other publications by the Rechen-Institut we list:

A. Kopff, Zur Vereinheitlichung der Berugssysteme von Sternkatalogen, *A. N.*, **270**, 73, 1940.

G. Stracke, Die Eros-Bewegung von 1930-40, Anh. der Preuss. Akad. d. Wiss., 1940, No. 7.

E. Rabe, Verschollene und nicht gesicherte Kleine Planeten, *Das Weltall*, **41**, 181, 1941.

E. Rabe, Bemerkungen Über die oskulierenden Elemente in der speziellen Störungsrechnung, *A. N.*, **272**, 208, 1942.

W. Gliese, Durchmesser—und Helligkeitsbestimmungen des ersten Schwassmann-Wachmannschen Kometen (1925 II) im Jahre 1941, *A. N.*, **272**, 269, 1942.

Katalog der Anhaltsterne für das Zonenunternehmen der AG, Veröff. No. 55, 1943.

In addition, several important mathematical tables by J. Peters.

6. *Heidelber. Veröffentlichungen:*

Bd. 12, No.

5: H. Klauder, Über die effektiven Temperaturen von Bedeckungsveränderlichen, *A. N.*, **270**, 286.
6: K. Reinmuth, Photographische Positionbestimmung von 207 Nebelflecken.
7: E. Kollnig-Schattschneider, Lichtelektrische Beobachtungen veränderlicher Sterne, *A. N.*, **271**, 85.
8: S. Temesváry, Zur Theorie der neuen Sterne.
9: K. Himpel, Über den Lichtwechsel von UZ Tauri und X Virginis, *A. N.*, **272**, 60 (10).

Bd. 13:

M. Brendel und K. Boda, Tafeln zur Verwandlung von Rektaszension und Deklination in Länge und Breite auf 0°.001.

Bd. 14, No.

1: H. Vogt, (I) Zur Theorie des Sternaufbauers; (II) Entartung im sterninnern; *Abh. d. Heidelberg Akad. d. Wiss.*, 1940.
2: K. Himpel, Zum Problem der vermissten Sterne, *A. N.*, **272**, 271 (14).
3: H. Vogt, Konvektion im Sterninneren.
4: H. Vogt, Zur kosmologischen Deutung der Spiralnebel.

Bd. 15, No.

1: W. Lohmann, Der Dichtegradient in Sternatmosphären, *A. N.*, **273**, 74 (14).
2: E. Kollnig-Schattschneider, Die veränderlichen Sterne im Kugelhaufen M 13, *A. N.*, **273**, 145 (14).
3: H. Klauder, Bemerkung uber den Koeffizienten der Strahlungsviskosität, *A. N.*, **273**, 189.

Mitteilungen:

*42: H. Vogt, Das Problem der Spiralnebel, 1940.
43: H. Vogt, Die Energiequellen der Sterne, *Scientia*, **71**, 101, 1942.
*44: Kubach, Bericht über die Kopernikus-Gesamtausgabe, 1943.
45: H. Vogt, Die chemische Zusammensetzung und die Entwicklung der Sterne, 1944.

Books:

H. Vogt, Aufbau und Entwicklung der Sterne, Leipzig 1943.

**In press,* in *Astr. Nachr.:*

H. Vogt, Der Einfluss der Rotverschiebung auf die scheinbaren Helligkeiten der aussergalaktischen Nebel.

H. Klauder, Über die Verteilung der Rotationsgeschwindigkeiten der Sterne.

J. Groeneveld, Lichtelektrische Beobachtungen ausgewählter veränderlicher Sterne.

*In press, book: H. Vogt, Die aussergalaktischen Nebel, Leipzig.

7. *Munich:*

W. Rabe, Micrometermessungen von Doppelsternen, *Veröff. Sternwarte München,* Bd. 2, Nr. 1, 1939.

8. *Göttingen:*

The last publications received from Göttingen before the war were issued late in 1940. Since that time have appeared:

Veröffentlichungen:

69: H. Kienle, J. Wempe und F. Beileke, Die absolute Intensitätsverteilung im kontinuierlichen Spektrum des mittleren A0-Sternes, 1940.

70: O. Heckmann, Geodätische Linien und Newtonsche Bewegungsgleichungen, 1941 (10).

71: W. Fricke, Über die Relaxationszeit in Sternsystemen, 1941 (8).

72: K. O. Kiepenheuer, Über die Austrahlung der Sonne im fernen Ultraviolett; I, Theorie der chromosphärischen Eruptionen, 1941 (4, 9).

73: P. ten Bruggencate, Über die Natur der Fackeln auf der Sonnenscheibe (Photometrie von Fackelgebieten), 1942 (9).

74: P. ten Bruggencate und H. Müller, Untersuchungen der Granulation der Sonne, 1942 (9).

75: P. ten Bruggencate, Zür Lindblad'sschen Rotations Theorie der Milchstrasse, 1943.

77: P. ten Bruggencate, Zur Theorie der Protuberanzen, 1944.

78: P. ten Bruggencate und H. von Klüber, Temperatur und Elektronendruck in Sonnenflecken, 1945.

Other publications issued from Göttingen:

O. Heckmann, Zur Kosmologie, *Nachr. Gesell. d. Wiss. Gött.,* Bd. 3, No. 15, 1940.

P. ten Bruggencate, Bemerkung zur anschaulichen Ableitung der Oortschen Formeln für die differentielle galaktische Rotation, *A. N.,* **274**, 1943.

P. ten Bruggencate, Wasserstoffhäufigkeit und Turbulenz in der Sonnenatmosphäre, *V. J.,* **76**, Heft 4, 1941 (9).

P. ten Bruggencate, Zum 400. Todestag von Nikolaus Coppernicus, *Gött. Gelehrte Anz.* 205, Nos. 5 and 6, 1943.

P. Jordan, Über die Entstehung der Sterne, *Phys. Zeits.,* **45**, No. 9-12, 1944.

P. Jordan, Zur Theorie des Farbensehens, *Phys. Zeits.,* **45**, No. 16-18, 1944.

Seven publications were obtained in ***manuscript*** form:

P. ten Bruggencate, Die Anregungstemperatur und die wirksame Schichtdicke für Fraunhoferlinien in der Sonnenatmosphäre, *Zeits. f. Ap.,* **23**, 119, 1944.

P. ten Bruggencate, Die Alterbestimmung von Sternen; ein Beitrag zur Jordan'schen Kosmologie, *Nachr. Akad. Wiss. Gött.*

P. ten Bruggencate, Zur Mitte-Rand-Variation der Fraunhoferlinien auf der Sonnenscheibe, *Naturwiss.*

W. Becker und P. ten Bruggencate, Über ein neues Konstruktion-

sprinzip beim Spektrohelioskop und beim Spektroheliographen, *Zeits. f. Instr.*

W. Becker, Über die Notwendigkeit einer Reform der astronomischen Integralphotometrie, I. (Written in Vienna.)

W. Becker, Kolorimetrische Untersuchung an offenen Sternhaufen in den Standard-Spektralbereichen der Integralphotometrie; N.G.C. 7654 (M 52) und Umgebung. (Written in Vienna.)

P. Jordan, Zur Theorie entartener Sterne.

9. *Berlin-Babelsberg. Veröffentlichungen:*

*Bd. XII, Heft 5: L. Courvoisier, Katalog von 1668 Reststernen des Zonenunternehmens der *A. G.*, 1941 (10).

Kleinere Veröffentlichungen:

*22: H. Schneller, Katalog und Ephemeriden Veränderlicher Sterne für 1941; issued in 1940.

23: C. Hoffmeister, Beobachtungen der Leuchtstreifen in Südwestafrika, 1940.

*24: C. Hoffmeister, Die veränderlichen Sterne der nördlichen Milchstrasse, Teil II, 1941.

*25: H. Schneller, Katalog und Ephemeriden Veränderlicher Sterne für 1942 (1941).

*26: (Title not available, but probably same for 1943), 1943.

27: C. Hoffmeister, Beiträge zur Kenntnis des Lichtwechsels von 326 veränderlichen Sternen am Südhimmel, 1943.

28: P. Ahnert und C. Hoffmeister, Die veränderlichen Sterne der nördlichen Milchstrasse, Teil III, 1943.

Katalog und Ephemeriden Veränderlicher Sterne für 1944, was destroyed by fire.

Babelsberg issued further many articles in *A. N.*, *Zeits. f. Ap.*, *Beobachtungs Zirkulare*, *Die Sterne*. Also, a new series was started, *Mitteillungen Veränderlicher Sternen* (MVS), of which 48 had appeared by the end of 1943.

10. *Potsdam.* The last of the *Publikationen*, No. 96, was issued in 1939. *Mitteilungen* 1-12, which appeared in 1940-41, have been circulated in the U. S. by *C. D. A. L.* One additional issue, No. 13, appeared in 1942: *W. Becker und W. Strohmeier, "Spektralphtometrische Untersuchungen an δ Cephei-Sternen, VIIIa." A number of summarizing articles were published by Kienle, Wurm, and von Klüber, of which we cite a few:

*K. Wurm, Die Neuen Sterne (Novae und Supernovae), *Naturwiss.*, **28**, 735, 1940.

*H. Kienle, Das kontinuierliche Spektrum und die Farbtemperatur der Sonne, *Naturwiss.*, **29**, 124, 1941.

*H. Kienle, Farbtemperatur und effektive Temperatur der Sterne, *Forsch. und Fortschritte*, **17**, 117, 1941; Research and Progress VII, 220, 1941.

*H. Kienle, Die empirischen Grundlagen des Masse-Leuchtkraft-Gesetzes, *Ergebnisse der exakten Naturwiss.*, **20**, 89, 1942.

*K. Wurm, Zur Konstitution der Venusatmosphäre, *Naturwiss.*, **29**, 471, 1941.

*K. Wurm, Das Spektrum des Ro-Sternes HD 182040, *Naturwiss.*, **29**, 686, 1941.

*K. Wurm, Moleküle im interstellaren Raum, *Naturwiss.*, **29**, 694, 1941.

W. Becker published his book, "Sterne und Sternsysteme," Leipzig,

1942, but the 8th edition of "Newcomb-Engelmann's Populäre Astronomie" evidently did not get completed.

11. *Hamburg-Bergedorf. Astronomische Abhandlungen:*

Bd. V, No. *2*: A. Günther, Spektralphotometrische Untersuchungen von δ Cephei-Sternen, 1939.

3: R. Schorr, C. Vick und J. Larink, Die Beobachtungen des Planeten 433 Eros während des Opposition 1930-31, 1939 (10).

4: F. W. Mävers, Untersuchungen der offenen Sternhaufen NGC 7092 (M 39), NGC 7209 und NGC 7243, 1940 (8).

Mitteilungen:

46: J. Hellerich, Bemerkung zur Dichteverteilung bei den δ Cephei-Veränderlichen, 1939.

47: A. Schwassmann, Die Bestimmung der räumlichen Verteilung der Sterne als Ziel des Unternehmens der Bergedorfer Spektraldurchmusterung, 1940.

48: J. Hellerich, Über die Beziehung zwischen den Amplituden der Licht- und Geschwindigkeitskurven bei den δ Cephei-Veränderlichen und verwandten Typen, 1940.

49: O. Heckmann, Der Einfluss der atmosphärischen Dispersion bei Van Biesbroecks Bestimmung der Aberration eines aussergalaktischen Nebels, 1942 (8).

50: J. Larink, Über die Aufstellung eines Generalkatalogs schwacher Sterne, 1942 (14).

51: K. Wurm, Die Natur der Kometen, 1943.

52: E. Kopff, Untersuchung der offenen Sternhaufen IC 4665, NGC 6633, IC 4756, 1943.

53: A. A. Wachmann, Über einen neuen Nebelhaufen in Ursa Major, 1943.

54: O. Heckmann, Skizze eines neuen Spektroheliographen, 1944.

55: O. Heckmann, Das statistische Gleichgewicht eines freien Systems von Massenpunkten, I, 1944.

Finally, the *Jahresbericht* for the years 1939, 1940, 1941, and 1942, as well as some short papers on observations in the *A. N.* and *Beobachtungs Zirkulare*.

Heckmann's useful book, "Theorien der Kosmologie," Berlin, 1942, has been mentioned before.

12. *Fraunhofer Institute.* Publications have been listed and reviewed in the text above, except:

K. O. Kiepenheuer, Die Ausstrahlung der Sonne im fernen Ultraviolett, *V. J.*, **76**, Heft 4, 1941 (9). *Cf.* also *Göttingen Mitteilung* No. 72.

FOOTNOTES

[1] *Vierteljahrsschrift d. A. G.* (= *V. J.*), **79**, 1, 1944.

[2] *Veröff. Sternwarte München*, Band 2, No. 1.

[3] Earlier Maj. Grotrian was in command of a technical company (Forschungs-Kompanie) composed of student soldiers that manned the chain of ionosphere stations from Tromsö, Norway, to Syracuse, Sicily.

[4] Also taken from Uccle was the 1-meter (f/3) reflector. It was removed by the Wehrmacht with mounting in June and July, 1940, with technical assistance from Zeiss. It was first used on the Channel coast (infrared observations on shipping). The remnants of the instrument are now reported to be at Gdynia, Poland.

[5] Katalog der Anhaltsterne für das Zonenunternehmen der *A. G.* (nach Beobachtungen an den Sternwarten Babelsberg, Bergedorf, Bonn, Breslau, Heidelberg, Leipzig und Pulkowo), *Veröff. d. Kopernikus-Instituts* Nr. 55, 1943.

[6] L. Courvoisier, Katalog von 1668 Reststernen des Zonenunternehmens der *A. G.*, *Veröff. Berlin-Babelsberg*, Band XII, Heft 5, 1941.

[7] BHF = Bevollmächtigter für Hochfrequenz Forschung, or plenipotentiary

for high frequency research, being the chief of the Reichsstelle für Hochfrequenz Forschung (see p. 270).

[8] According to one source most of the Belgrade Observatory was shipped off during the summer of 1944, probably for use by K. Walter in Poland. Others also had designs on the Belgrade equipment (see section V).

[9] Professor Fell reports that the transit instrument of Graz was damaged with bayonets. *Cf.* also section V, 2.

[10] *V. J.*, **78**, 136, 1943.

[11] *V. J.*, **79**, 35, 1944.

[12] O. Struve, *Ap. J.*, **100**, 105, 1944. G. Gamow and J. A. Hynek, *Ap. J.*, **101**, 249, 1945.

MacDonald Observatory, Fort Davis, Texas.

The Development of Astronomical Photometry

By HAROLD F. WEAVER

(Continued from page 230)

PERIOD III

The General Photometric Problems of the Third Period

The third period of astronomical photometry began in 1844 when Fizeau and Foucault, just five years after the photographic process became generally available, compared the brightness of the sun to that of a carbon arc by means of photography.

Bond's Work. A few years later, in 1850, the first stellar photograph was made by J. A. Whipple, a Boston photographer working at the Harvard College Observatory under the direction of W. C. Bond, with the early daguerreotype plates and the Harvard 15-inch equatorial telescope. Vega was readily photographed, and α Geminorum showed an elongated image thus revealing its duplicity, but, owing to the very low sensitivity of the plates, Polaris would give no photographic impression regardless of the length of the exposure time, and the experiments were therefore discontinued.

By 1857 the speed of photographic plates had been increased sufficiently to make it possible to photograph stars of the sixth or seventh magnitude with the 15-inch telescope, and it therefore seemed feasible to Bond to renew the experiments in stellar photography. In describing his findings during this second set of experiments Bond stated,[15] "the magnitude of a star manifests itself in two idependent ways. In the diameter of images of different stars with the same exposure and in the length of time necessary to produce the first visible trace of chemical action."

Bond continued his work in stellar photography, and finally reached

[15] *A. N.*, **48**, 1, 1858.

the conclusion presented in his now classic paper[16] in the field of photometry that the growth of the photographic image of a star was proportional to exposure time, that is, that the diameter, y, of the photographic image of a star could be represented as a function of exposure time by an expression of the form

$$y^2 = Pt + Q$$

where P and Q are constants, and t represents exposure time. He suggested that the ratio of exposure times required for stars of different magnitudes to form images of the same size, or, alternatively, that the ratio of the reciprocals of the areas of objectives affording images of equal diameter in equal exposure times, would be a measure of the ratio of the photographic magnitudes of those stars.

Summing up his observations, Bond concluded that there would be three particular ways in which his "proposed system of magnitude determination would have an unquestionable advantage over that in common usage, provided that the chemical action of starlight should be found . . . energetic enough to furnish accurate determinations of its amount. 1. It would be less liable to be affected by individual peculiarities of vision. 2. There would be less room for discordance between observers, or for disagreement between the conclusions of the same observer at different times, as to the quantities or proportions constituting the various grades of magnitude. 3. Lastly, it would meet perfectly the greatest of the many difficulties of the problem—the comparison of stars exhibiting diversity of color."

It is clear to us now that photographic photometry does not fulfill all of the high hopes or offer all of the advantages suggested by Bond for his "proposed system." Unfortunately, the combination of telescope plus photographic plate is a potential source of all the errors found in the human eye, Purkinje effect, distance from center correction, color equation, and so forth, and there is ample opportunity for different observers to disagree. These difficulties were generally discovered only much later, however, and could certainly not be forseen by Bond, whose early investigations gave direction to, and served as a basis for, much of the photometric work carried on later.

For some years following Bond's pioneering work, little was done in the field of photographic photometry. Numerous observers perfected the techniques of pictorial astronomical photography and several improvements in photographic materials were made. In 1871 the first successful gelatin silver bromide emulsion was produced. This was further improved and speeded up by chemical and heating treatments discovered in 1878. In 1881 A. A. Common, using these new plates, photographed stars too faint to be seen visually in the largest telescope then in existence, and the field of astronomical photography was thus opened for full exploitation.

[16] *A. N.*, **49**, 81, 1859.

Pickering's Early Work. In 1882 a series of preliminary experiments was begun at the Harvard College Observatory by E. C. Pickering[17] to determine the feasibility of using star trails obtained with a stationary camera to establish magnitudes. These were to be determined by comparison of the trails with a standard graded series of trails which was assumed to define a Pogson Normal Scale. This standard was constructed by pointing the camera at the north celestial pole and taking a series of exposures with different lens apertures. The areas of these apertures were taken as measures of the light transmitted by the objective, and thus differences in apparent magnitude between the sections of trails recorded on the plate were known. The multi-section trail of one star on this plate was selected as the standard, and thereafter all measurements were made with it. In making these measurements the magnitude represented by any trail was estimated to the nearest tenth of a magnitude by direct interpolation between the segments of the standard.

A second method of establishing a standard magnitude scale was suggested by Pickering, but was apparently applied with less success than the method of apertures. It involved attaching to the center of the objective a prism of very small angle. Light falling on this prism was deviated slightly, and hence each star image formed on the plate in the normal manner by the light passing through that part of the objective not covered by the prism had a faint displaced companion arising from the light passing through the prism. Since the ratio of area of prism to area of the free lens was known, supposedly the ratio of brightness between main image and companion was known. By means of these pairs of images of constant magnitude difference, it was possible to establish an absolute scale of magnitudes.

In view of the general success of the first tests, a second series of photometric experiments was begun by Pickering in 1885 with a reworked Voigtlander lens of eight inches aperture and 45 inches focal length. Experiments in astronomical photography were also in progress at other observatories. In the same year J. C. Kapteyn joined with Gill of the Royal Observatory at the Cape of Good Hope for the construction of a catalog of the southern stars, the division of labor to be that Gill would take the plates and Kapteyn would measure positions and determine photographic magnitudes for all the stars visible on them. This cooperation, as is well known, culminated during the period 1896-1900 in the publication of the *Cape Photographic Durchmusterung.* Likewise in 1885 the Henry brothers at the Observatory of Paris began photographic experiments with a specially constructed astronomical camera of 33 centimeters aperture which was later to serve as a model for the astrographic cameras.

Pickering, in discussing the establishment of photographic magni-

[17] *Mem. Am. Acad. of Sci.*, **11**, 179, 1888.

tudes in this second set of experiments, stated that there were three main avenues of approach to a solution of the problem through the use of trails, point images, or surfaces, which could be obtained if the stars were photographed out of focus or as spectra. Although he investigated all of these approaches, the greater part of his work was carried out with trails which were at first thought to offer the most satisfactory method of allowing the stars to record themselves. By means of trails he established for a group of polar stars and for a group of equatorial stars a photographic magnitude scale which was independent of visual magnitudes except for zero point. He established a similar scale in the Pleiades by means of point images.[18]

In establishing these magnitudes from trails, Pickering made use of a standard scale of graded trail sections as mentioned previously or, for establishing magnitudees in the Pleiades an analogous scale of point images made by photographing a star field with a lens of constant aperture but with a series of exposures of regularly increasing exposure time. For each series of measurements it was assumed that the scale of the plate being measured was identical with that of the standard series of images; that the standard image scale, once calibrated by means of the aperture or exposure times with which it was taken, could be used thereafter without further calibration. The zero point of any photographic magnitude sequence was established by making the average of the photographic magnitudes agree with the average of the visual magnitudes of the same stars.

The general results obtained by Pickering were encouraging from many points of view, and his analysis of these results afforded con-

[18] In the early literature on photographic photometry there is much misunderstanding in regard to the value of photographic magnitudes, and much confusion about visual and photographic scales. One of the clearest statements of the period in connection with these questions was made by Pickering in *Memoirs of the American Academy of the Arts and Sciences*, **11**, 202, 1888: "The fact that the photographic magnitude will vary greatly with the color can scarcely be called an objection. We wish to know the true relative intensities of the light of the stars, and not merely their relative brightness as judged by the eye. As long as the spectra of the objects compared are the same, that is, as long as the light of any given wave length emitted by each bears the same proportion to the whole, all methods of measurement will give the same result. In other words, the relative intensity will appear to be the same whether it is measured by the eye or by the sensitive plate. This is the more precise statement of the case which is commonly expressed by saying that the color is the same. When the spectra differ, and the colors are unlike, no single number will properly express the ratio of the two lights. The only true comparison is by a series of numbers which express the ratio of the light for each different wave length. When, therefore, we say that a red and a blue star appear equally bright, we merely indicate that the entire radiation affects the eye equally. The visual result will not in general differ much from what would be attained if all the light had a wave length of .00006 cm., or 6000 ten-millionths of a millimeter. The photographic plate gives a more precise summing up (!) of all the radiations, since no difference of color appears in the final picture, but the mean wave length is not far from 4000 ten-millionths of a millimetre. Accordingly, blue stars will appear comparatively much brighter in the photograph, and red stars brighter to the eye. Their relative light can be fully determined only by the comparison of spectra. . ."

siderable insight into the sources of error to be guarded against in photographic photometry. Pickering found that the probable error of a magnitude estimate was less than a tenth of a magnitude, but that his errors did not appear to be wholly accidental. It was quite clear from his analysis, for example, that the magnitudes of one plate differed systematically from those of another plate. He was forced to the conclusion, therefore, that he could not assume, as he had, that his standard image scale, once calibrated, could be used directly for all future measurements without further change of that calibration. He found that there was a distance-from-center correction, that a star would have, apparently, a different magnitude depending on whether it was near the center of the plate, or at some distance from the center, and that the camera thus behaved rather like the human eye. Likewise he found a distinct systematic error in his results which depended upon the hour angle of the camera.

The method of trails was found to be generally unsatisfactory owing to the necessity for applying corrections to the magnitudes obtained because of the compression of the trails with increasing declination. These corrections, unfortunately, could not be determined by fundamental means then available, and, moreover, very probably varied from exposure to exposure owing to the effects of seeing.

By the time Pickering had reached and published these conclusions the preliminary work on the *Cape Photographic Durchmusterung* had been completed; Kapteyn had already reduced the first plates. Moreover, a larger and more extensive catalog had been started as a new chapter in astronomical history which was to occupy astronomers for many years thereafter.

The Astrographic Catalog and the Early Attempts to Establish a Magnitude Scale. Influenced by the great success achieved in astronomical photography by the Henry brothers and urged by Admiral Mouchez, director of the Paris Observatory, the French Academy of Sciences called an international congress to meet in April, 1887, to discuss the feasibility of constructing a photographic chart of the entire sky. It was decided at that meeting that such a cooperative venture, the largest ever to be attempted in astronomy, was desirable and possible, and many observatories from all over the world agreed to take part in the work. Those participating in this program of the *Carte du Ciel* and the *Astrographic Catalog* were to have as their principal aims the establishment of a general photographic map of the sky, the securing of data which would give positions and photographic magnitudes of the stars to a given brightness with the highest precision possible, and the provision for the best means of utilizing, then and in the future, the data on the photographs they were to take.

In achieving these aims the Congress planned to have all the instruments used in the program photographic refractors of the same design,

of 33 cm aperture and 343 cm focal length; the objectives were to be similarly achromatized (for λ 4300); the plates used were to be the same at all observatories; photographs for the charts were to show stars of magnitude 14, measurements of coordinates were to be completed for all stars brighter than or equal to magnitude 11.

The problems involved in seeing this ambitious program through to completion were undoubtedly not realized by the members of the Astrographic Congress at the time of the first meeting, or for many years thereafter. Not one of the smallest problems was the photometry involved in the construction of the catalog. No photographic magnitude scale was available; the properties of photographic plates were poorly understood; the law of reciprocity was quite generally accepted. At the time of the first meeting of the Congress the papers dealing with Pickering's photometric researches, by far the most fundamental of that period, had not been published—the experiments had not even been completed. (Moreover, Pickering's work was criticized when it did appear, and seems to have been discounted rather generally.)

Most photographic magnitudes were at that time determined from the visual magnitude scale; most photometric reductions were made by means of empirical mathematical formulas, which, through their arbitrary character and inflexibility, introduced many systematic scale errors into the resulting magnitudes. The general procedure for determining magnitudes involved measuring the diameters of the star images, which were known to increase with increasing brightness of the star being photographed, and, then, by means of the known visual magnitudes of some of the stars find, by least squares, the constants in some formula connecting image diameter and magnitude. Small numbers of stars did not, of course, give good values of these constants because of the evident differences in photographic and visual magnitudes of the individual stars. But by making use of large numbers of stars the law of averages, it was hoped, would come to the aid of the observer, and he would be able to obtain good values of his constants. The number of constants generally used in a magnitude diameter equation was two; the number of equations found in the literature is legion. As a few examples of these formulas, we list the following:

Charlier	$m = a - b \log D$
Christie	$m = a + 2.5 \log (t - b D)$
Kapteyn	$m = a/(b + D)$
Pritchard	$m = a - b \log (D/t^{1/a})$ $(a = 3.8)$
Scheiner	$m = a + bD$
Turner	$m = a - b D,$

where a and b are constants, m represents magnitude, t time, and D image diameter. In more recent times (1922, 1924) more elaborate formulas have been proposed: Ross has suggested

$$a + bm = (D + c)^{1/3}$$

and Bemporad

$$D = a + b\,(m-7) + c\,(m-7)^2 + d(m-7)^3,$$

where, as before, D and m represent, respectively, diameter and magnitude, and a, b, c, and d are constants. All these formulas lack flexibility, and are mere interpolation devices which may well introduce systematic errors, or are founded on theoretical discussions of oversimplified assumptions, and hence are not recommended for use. The particular form of equation for fitting the observations most satisfactorily is, of course, a function of the objective, its color curve, its degree of correction for aberrations, the color sensitivity of photographic plate being used, the "seeing" during the exposure, and so forth. This was not clearly understood at the time of the first Astrographic Congress, however, or for some time thereafter, and as a result of this lack of understanding there were published many papers on the "best" form of the equation.[19]

One of the most difficult problems facing the members of the Astrographic Congress for some years after the formation of the group was the establishment of some criteria which would enable the observer to know which stars on his plate were stars of the eleventh magnitude and which stars were of the fourteenth magnitude. Upon the establishment of satisfactory criteria for these magnitudes depended the amount of work faced by the group, for not only was it necessary to know what length of exposures to give in order to reach the fourteenth magnitude, but also it was necessary to know at what size of star image it was necessary to stop measuring position, for the number of stars in the sky increases by approximately 10 per cent for each tenth-magnitude one goes fainter than magnitude eleven. Most of the suggestions for establishing the time necessary to photograph an eleventh magnitude star assumed the reciprocity law. It was proposed, for example, to determine the time required to photograph a star of the ninth magnitude as determined from the *B.D.*, and then to multiply that time by $(2.5)^2$ in order to determine the time required to photograph an eleventh magnitude star. Such procedures could, of course, though it was not generally known then, lead only to erroneous results and false conclusions.

[19] D. L. Edwards (*M.N.*, **102**, 242, 1942) has made the interesting observation that a formula of the form

$$m = a - b\,(D - kD^2)$$

gives a very good fit to his observations of image diameters. The quantities m, a, b, and D in this equation have the same significance as in those discussed above. The quantity k is a variable dependent upon the color of the star. Edwards found

$$k = 10^{-5}\,(140 - 13c)$$

where c is the color index of the star under consideration. The coefficient affects primarily the bright stars of large D (in which Edwards was primarily interested) and is in essence a correction for Purkinje effect. The necessity of applying such a correction would exist in Edward's case, no doubt, regardless of the method of measurement used.

In 1891 Kapteyn proposed that the observers taking plates for the *Astrographic Catalog* make use of wire mesh screens which would be placed in front of the objective and would diminish the intensity of light transmitted by an amount equivalent to two magnitudes on the Pogson Normal Scale. With such a screen available any observer could easily extend the available magnitude scale by increments of two magnitudes. Kapteyn further proposed that each observer should take, from time to time, certain standardization plates of certain standard regions to be chosen by the Congress in such a way that one region would always be at a convenient zenith distance for any observer.

Unfortunately, this excellent plan, which, in many ways, would have standardized the early photometric work of the *Astrographic Catalog*, never materialized. Standard regions were chosen and magnitude[20] sequences were set up by Pritchard with a wedge photometer. The screens, however, were never used, for the Commission appointed by the Congress to make and test them reported its findings to be unfavorable, a situation brought about, no doubt, by the newness of the principle involved, and some testing procedures which were apparently not altogether sound.

In 1893 Kapteyn presented to the Committee of the *Carte du Ciel* a preliminary account of his discovery of the variation of the average color of the stars with galactic latitude (a discovery made from his photometry in the *Cape Photographic Durchmusterung*), and he and Gill pointed out some of the important consequences of this phenomenon on the photometry of the *Astrographic Catalog* as it was then being carried out by means of image-diameter-visual-magnitude formulas. In order to eliminate or at least minimize the systematic errors which would result from the "Kapteyn phenomenon" and the continued use of these formulas, Gill suggested that the ten Kapteyn-Pritchard regions then available be compared, one by one, with a group of stars near the north pole in the manner now used for making polar comparisons. From each of these comparisons a magnitude scale could be established for a certain polar sequence from the supposedly know magnitudes of the Kapteyn-Pritchard Areas. The scales established for the Polar Sequence from the various standard regions would not agree, however, inasmuch as the photographic scales of the standard regions were inhomogeneous owing to the Kapteyn phenomenon. The plan was then to adopt the average of the different polar scales as the true photographic scale. Working in the reverse direction, the magnitudes of the Kapteyn-Pritchard regions could then be redetermined from the magnitudes of this average polar scale, and thus a homogeneous system of photographic magnitudes would be available. It was then proposed to photograph one Kapteyn-Pritchard area each night in the same manner as the regular plates in the series were photographed and in this manner pro-

[20] Visual magnitudes.

vide a check on the magnitude scale of the *Carte du Ciel* and the *Astrographic Catalog*.

While this suggested procedure was far better than any that had been proposed up to that time, and is of interest because it suggested the use of a polar sequence, it was not until 1909 that a completely satisfactory means of determining magnitudes for stars in the *Astrographic Catalog* was adopted. It is for this reason that, generally speaking, no satisfactory magnitudes were determined and that the *Astrographic Catalog* has unfortunately lost much of its value in the field of statistical astronomy.

Pickering's early suggestion in regard to the use of extra-focal stellar images for photometric purposes had already been mentioned. Just before the turn of the present century K. Schwarzschild of the Kuffner Observatory independently made the same suggestion and undertook a number of very careful studies of the photometric uses of such images. With these extra-focal images the size of image was of no importance; all images were of the same size, and the brightness of a star recorded itself by the degree of darkening of the star's image. In order to evaluate this degree of darkening and hence the brightness of a star, Schwarzschild made use of an image scale composed of a series of images of the same star taken with exposures of durations which varied in geometric ratio. The degree of darkening of any star image was estimated by comparison with this scale as in Pickering's work with points and trails. The general method of reducing the darkening values thus found to magnitudes involved, in Schwarzschild's first work, the use of formulas in which the constants were evaluated from measurements of A-type stars of known visual magnitudes.

The method of reduction in these early extra-focal studies thus offered no great advantage over the work with focal images. Furthermore, some difficulties were encountered in achieving evenly darkened images owing to various lens aberrations, and, because of the loss of the effectiveness of the light through its spreading over an appreciable area in the out-of-focus images, only relatively bright stars could be observed. The importance of this early work arises primarily from the fact that it marked the first extensive test of the extra-focal method following Pickering's original suggestion, and was the beginning of the series of studies in extra-focal photometry carried on by Schwarzschild—studies culminating in the invention of the Schraffierkassette and the publication of the *Göttingen Actinometrie*—and also the beginning of extended series of extra-focal photometric researches carried on by many observers at many observatories. It marked the true start of a new method of attack on the photometric problem.

The Modern Period: Investigation of Means of Establishing Scales. In his early extra-focal work Schwarzschild, from studies of the photographic process of a theoretical nature, attempted to derive a mathe-

matical expression involving the magnitude of a star, the degree of blackening of its extra-focal image, and its exposure time. In 1899 these studies had reached an advanced stage and were presented by Schwarzschild[21] in his now classic paper on photographic photometry in which he defined the exponent p (which now bears his name) in the familiar equation[22]

$$S = f(I \cdot t^p),$$

and, through the photographic experiments which he performed and described, we began to gain a more precise knowledge of the nature of a photographic plate, and to enter what may be called the modern period of photographic photometry. The history of the first decade of this modern period is one primarily of the development of methods of establishing fundamental magnitude scales; the history of the succeeding decades that of applications of these and related methods.

In 1901 C. Wirtz,[23] following ideas previously presented by Kapteyn and by Schwarzschild, made use of an objective screen, a simple wire mesh placed over the objective, to reduce the apparent magnitude of a star by a known amount from one exposure to another, and, by means of the data thus obtained, was able to establish a fundamental magnitude scale. Essentially, Wirtz took two out-of-focus exposures of the same star field, one exposure being taken with the free objective, the second exposure (of the same duration and on the same plate as the first, but with the telescope slightly displaced from its original position) being taken with a grating placed over the objective. For every star in the field there thus appeared on the plate two images, side by side but of different degrees of blackening, which had been produced by star images whose intensities bore a known relationship to each other. From this relationship and the observed degrees of blackening it was a simple matter to set up a fundamental magnitude scale.

In 1906 A. Wilkins[24] showed how Wirtz's results could be improved by using better gratings, and in that same year Schwarzschild presented his well-known paper[25] on the determination of magnitude scales from photographs on which there were two exposures of the type taken by Wirtz and Wilkins. Schwarzschild's generalized formulation of the problem of scale determination from such photographs as an Abel functional equation, and his solutions of this equation under various sets of assumptions have served as a basis for the establishment of all modern magnitude scales.

Likewise in 1906 Kapteyn, in his *Plan of Selected Areas*, discussed,

[21] *Publ. v. Kuffnerschen Sternw.*, Band V, 1899.

[22] In which S represents the degree of blackening on the plate, I the intensity of light incident upon the plate, t the duration of the exposure, and p the so-called Schwarzschild exponent, originally presumed to be a constant.

[23] *A. N.*, **154**, 317, 1901.

[24] *A. N.*, **172**, 305, 1906.

[25] *A. N.*, **172**, 65, 1906.

among other things, the problem of establishing a rational scale of photographic magnitudes which would be homogeneous over the entire sky, and proposed a method for its solution. Kapteyn's method of setting up a magnitude scale in any area of the sky made use of a neutral half-filter, a filter one-half of which was homogeneous and clear and absorbed no light (or very little light), the other half of which was homogeneous, neutral, and moderately dense, and had a known absorption constant. This filter was put in contact with the photographic plate, and a photograph taken of the area in which a scale was desired. At the completion of an exposure through the filter, the filter was rotated through 180°, that is, the clear and filter halves were made to interchange positions, the plate or telescope was shifted, and a second exposure, of the same duration as the first, and of the same field was taken on the same plate. Thus each star left on the plate two images, and the pattern of large and small images of each star, one through the clear part of the filter, the other through the dense part of the filter was interchanged on the two halves of the plate. Through consideration of image pairs on the two halves of the plate a fundamental magnitude scale could be set up since the magnitude corresponding to the average of any two small images differed from the magnitude corresponding to the average of the analogous large images by just the filter constant. In order to achieve homogeneity of the magnitude system over the entire sky, Kapteyn proposed that the areas in which scales had been established by the half-filter method be compared among themselves in a systematic manner.

Time has shown that with slight improvements and modifications this general method proposed by Kapteyn in 1906, but also tried earlier, in 1900, by Schwarzschild is one of the most satisfactory methods known today for establishing a magnitude scale.

Another innovation in the field of photometry was announced in 1906 when Meyermann and Schwarzschild[26] published a description of their Schraffierkassette, or "jigglecamera," a device which moved a photographic plate located in the focal plane of the objective in such a manner that each focal image produced a small area of uniform blackening on the plate. The image or pattern thus formed by each star was of the same size, generally resembled an out-of-focus image, and had all the advantages of accuracy of measurement inherent in the process of surface photometry. The production of these darkened areas by the Shraffierkassette method, however, avoided the difficulties customarily encountered in the use of extra-focal images owing to the irregular or uneven distribution of light caused by the various lens aberrations.

In 1907 Parkhurst and Jordan[27] described still another method of determining an absolute scale of photographic magnitudes that made

[26] *A. N.*, **170**, 277, 1906.
[27] *Ap. J.*, **26**, 244, 1907.

use of extra-focal images and a magnitude image-density calibration curve established from measurements of sensitometer spots impressed on the plate in the laboratory.

A year later E. S. King[28] reported his method of establishing a photometric scale by changing the position of the plate with respect to the focal plane of the objective and making use of the inverse-square law of intensity change.

During the years 1908 to 1910 Fabry[29] suggested and tried a method of surface photometry which, unfortunately, is not so well known as it should be. The method involved the use of a small auxiliary lens of focal length of the order of one inch which was placed in or near the focal plane of the telescope. The image of the telescope objective formed by this Fabry lens was then photographed in the light of the object under study, an object such as a star, a cluster, a nebula, or merely some portion of the sky.

With a telescope which possesses the unusual characteristic of giving perfectly satisfactory evenly darkened images, little is gained under ordinary circumstances through use of the Fabry method. In most instances, however, the light is more evenly distributed in the Fabry image than it is in the normal extra-focal image owing to the shortcomings of the average telescope. In addition, the method is capable of succeeding when even a perfect telescope would fail, as, for example, in giving images of uniform light distribution from irregular sources such as star clusters or nebulae.

The plates taken by the Fabry method were originally calibrated with a tube sensitometer as in the work of Parkhurst and Jordan, or, in later year, with neutral step wedges or sectors.

In 1910 Schwarzschild[30] suggested an improvement in the method of reduction used by Kapteyn in his half-filter method, and in addition proposed the use of a fine mesh half-screen placed between the objective and the plate in place of Kapteyn's filter which had been made by exposing one-half of a photographic plate to a controlled source of illumination.

E. Hertzsprung[31] devised still another method of establishing a fundamental or absolute scale of magnitudes in 1910, by taking advantage of the known constant magnitude difference between the central image and various order spectra that can be obtained for stars photographed through a parallel wire grating located before the objective.

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[28] *H. C. O. Annals,* **59.** It should be mentioned that in much of King's experimental work "pinhole cameras," that is, cameras without lenses, and having only clear apertures but of various sizes up to several inches for admitting the light of the object under study were used.

[29] *Ap. J.*, **31**, 394, 1910. Several other observers have tried the method with good results. See R. O. Redman, *M. N.*, **105**, 212, 1945, and a second paper by Fabry, *Ann. d'Astroph*, **6**, 65, 1943.

[30] *A. N.*, **183**, 297, 1910.

[31] *A. N.*, **186**, 177, 1910.

Pickering in the same year suggested that new ways of measuring photographic star images should be sought, and suggested that here was a possible application of a thermopile, bolometer, radiometer, or selenium cell.

Another type of photographic advance during this period was made through the perfection of means of determining visual magnitudes by photography. This involved the use of orthochromatic plates whose spectral sensitivity curves extended into the green, yellow, orange, and even red portions of the spectrum, and yellow filters. Many experiments in the construction of the necessary filters, and the determination of "photovisual" magnitudes were carried on very successfully at the Yerkes Observatory by R. Wallace, J. Parkhurst, and F. Jordan.

(To be continued)

The Planets in July and August, 1946

By LELAND E. CUNNINGHAM

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. Throughout July and August the sun will move southward, very slowly at first, but with steadily increasing rapidity; at the end of August it will still be nine degrees north of the equator.

Moon. The phases of the moon will occur as follows:

		C.S.T.
First Quarter	July 5	11 P.M.
Full Moon	14	3 A.M.
Last Quarter	21	2 P.M.
New Moon	28	6 A.M.
First Quarter	August 4	3 P.M.
Full Moon	12	4 P.M.
Last Quarter	19	7 P.M.
New Moon	26	3 P.M.

Evening and Morning Stars. At the beginning of the period there will be no morning star. The evening stars will be Saturn, Mercury, Venus, Mars, and Jupiter, in the order of their relative distances east from the sun. On August 9 Venus will overtake Mars. Saturn will become a morning star on July 21, and Mercury on August 2. During the first half of July, Mercury will be a rather conspicuous object low in the west during the evening twilight. Venus will be a brilliant evening object in the west throughout the two months, while Mars will be an inconspicuous object in the same general region. At the beginning Jupiter will be a bright object near the meridian at dusk, but by the end of the period it, too, will be in the general region of Venus, and intermediate in brightness between Venus and Mars. Saturn will be too near the sun to be seen, except possibly for the last few days of August.

Mercury. At the beginning of July, Mercury will be easily visible low in the western twilight. On July 5 it will reach its greatest elongation east from the sun. This occurs when the eastward motion of the sun and Mercury are the same. After that date Mercury will continue to move eastward, but much more slowly from day to day, until July 19, when it will be stationary. It will then retrograde until August 12, when it will again be stationary. Because of this retrograde motion, together with the steady eastward motion of the sun, it will rapidly lose its elongation east from the sun after July 5, will move into inferior conjunction with the sun on August 2, that is, will be nearly in line between the earth and sun, and will then rapidly emerge from the vicinity of the sun into greatest western elongation from the sun on August 20. It will be visible for a few days near this date very low in the eastern sky just before sunrise. Since it will then be near perihelion, that is, near the closest point in its orbit to the sun, it will appear relatively close to the sun. On the other hand, at eastern elongation on July 5 it will be near aphelion, that is, near the farthest point in its orbit from the sun, and so will appear relatively distant from the sun. Thus it will be much easier to see near eastern elongation on July 5, than near western elongation on August 20.

Venus. Just as it has been doing since February 1, Venus will continue to move eastward a little faster than the sun. It will be a conspicuous object each evening. On the evening of August 30 Venus, Jupiter, and the moon will be lined up in a brilliant spectacle. They will be in the order named, and spaced uniformly at about seven lunar diameters. At the same time Spica will be seen, but much fainter, about half a lunar diameter below Venus.

Mars. Mars will move eastward across Leo and Virgo, but more slowly than the sun, and so will set a little earlier each night, just as it has been doing since January 14. Near August 9 it will be about the diameter of the moon north of Venus. It will not be a conspicuous object at any time.

Jupiter. Jupiter will be moving slowly eastward a few degrees north of Spica. The phenomena of the satellites will not be easy to watch because Jupiter will reach a low altitude so soon after dusk. On the evening of July 3 Satellite III will go into eclipse at 10:28 C.S.T., and on the evening of July 5 Satellite I will emerge from eclipse at 9:46 C.S.T.

Saturn. Saturn will be too close to the sun to be seen, except possibly for the last few days of August.

Uranus. Uranus will remain in Taurus, where it will be too close to the sun for observation in July. In August it may be observed with difficulty for a short time just before dawn.

Neptune. Neptune will be moving slowly eastward in Virgo. It may be observed with difficulty in July for a short time after dusk, but will be too near the sun for observation in August.

Berkeley, California, May 12, 1946.

Occultation Predictions for July and August, 1946

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from

the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1946	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
			h m	m	m	°	h m	m	m	°
July 10	47 Libr	5.9	1 33.2	−1.3	−1.4	148	2 47.9	−2.3	−0.5	261
13	λ Sgtr	2.9	0 52.3	−1.1	+0.9	103	2 13.6	−1.8	+0.6	278
18	257 B.Aqar	6.3	5 47.9	−1.9	+0.7	106	6 45.4	−1.0	+2.2	197
Aug. 3	623 B.Virg	6.5	23 46.6	−2.1	−0.9	89	0 55.6	−1.0	−2.4	331
4	μ Libr	5.8	23 46.8	−0.5	−2.8	177	0 35.0	−2.6	−0.1	243
9	CD—25°12793	6.3	0 6.6	−0.9	−0.8	148	1 5.3	−2.6	+1.4	233
14	τ Aqar	4.2	8 57.3	−2.0	−2.3	110	9 40.2	+0.3	+1.8	188
18	64 Ceti	5.7	8 48.7	..	..	131	9 9.7	..	..	163
18	ξ¹ Ceti	4.5	9 55.3	−3.9	−3.8	125	10 24.7	..	..	170
23	ω Gemi	5.2	6 58.7	+0.3	+1.2	85	7 51.3	0.0	+1.3	263
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
July 13	λ Sgtr	2.9	0 40.3	0.0	+0.1	134	1 40.7	−1.5	+1.8	251
18	257 B.Aqar	6.3	5 19.7	−0.9	+1.1	103	6 19.3	−1.1	+2.3	211
22	25 Arie	6.5	9 48.3	−0.9	+1.9	53	11 0.2	−1.4	+1.5	241
Aug. 3	65 Virg	5.9	2 42.3	−0.8	−1.9	120	3 49.2	−0.4	−1.8	293
14	τ Aqar	4.2	8 22.5	−2.0	−0.2	81	9 33.1	−0.7	+0.8	213
18	64 Ceti	5.7	7 59.0	−1.7	+1.1	90	9 0.1	−0.7	+2.5	202
18	ξ¹ Ceti	4.5	9 5.4	−2.1	+0.7	89	10 9.8	−0.8	+2.4	203
20	163 B.Taur	5.8	7 51.9	−1.4	+0.2	122	8 25.8	+0.5	+3.3	189
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
July 3	46 Leon	5.7	3 49.9	−1.8	+0.1	58	4 20.7	+0.7	−3.4	354
10	β Scor	2.9	7 35.1	−1.8	−0.4	66	8 39.0	−1.5	−2.7	323
10	56 B.Scor	5.1	7 35.6	−1.7	−0.3	65	8 38.7	−1.5	−2.7	325
22	25 Arie	6.5	9 28.7	+0.1	+2.3	24	10 17.6	−1.0	+1.0	277
Aug. 3	66 Virg	5.8	3 26.0	−0.7	−2.9	165	4 20.6	−1.4	−0.9	256
4	κ Virg	4.3	5 0.2	−1.2	−1.7	107	6 12.0	−0.6	−1.9	301
7	ω Ophi	4.6	2 52.5	..	..	49	3 33.0	−0.3	−3.9	357
8	191 B.Ophi	6.3	4 20.1	−2.2	−0.8	121	5 50.2	−2.3	−0.5	261
8	*b* Ophi	4.3	5 10.8	−2.5	−0.4	91	6 42.4	−1.9	−1.4	285
9	67 B.Sgtr	6.4	5 4.1	−2.2	−1.6	141	6 8.3	−2.1	+1.0	226
10	ψ Sgtr	4.9	6 56.3	−1.8	+1.0	42	8 6.3	−2.5	−1.8	299
14	τ Aqar	4.2	7 25.2	−1.6	+1.8	48	8 47.1	−2.2	+0.7	252
18	64 Ceti	5.7	7 27.9	−0.3	+1.7	63	8 29.4	−0.6	+1.8	238
18	ξ¹ Ceti	4.5	8 24.0	−0.5	+1.9	54	9 30.7	−1.1	+1.7	242
22	5 Gemi	5.9	11 51.4	+0.5	+3.3	23	12 30.5	−1.9	−0.7	309
23	48 Gemi	5.8	10 41.8	−0.1	+0.5	113	11 29.2	+0.2	+1.9	235
Occultations Visible in Longitude +98° 0′, Latitude +30° 0′*										
July 10	β Scor	2.9	8 5.0	−0.7	−1.1	90	9 11.5	−0.3	−1.5	288
10	56 B.Scor	5.1	8 5.4	−0.7	−1.1	89	9 11.5	−0.3	−1.5	289
13	CD—25°13170	6.2	1 1.9	−0.3	+0.2	117	2 12.1	−1.4	+1.0	270
18	257 B.Aqar	6.3	5 10.3	−0.5	−0.9	132	5 42.7	−1.1	+4.0	183
22	25 Arie	6.5	9 23.8	−0.8	+1.7	61	10 33.9	−1.2	+1.9	232
Aug. 3	65 Virg	5.9	2 57.3	−0.9	−2.4	142	4 1.3	−0.6	−1.2	274
3	66 Virg	5.8	3 57.2	−0.5	−2.9	161	4 42.1	−0.2	−0.4	249

				h	m	m	m	°	h	m	m	m	°
Aug.	4	95	Virg	5.5	0	53.2	—3.4	—0.1	81	1	59.2	—0.9	—3.2	348
	7	ω	Ophi	4.6	4	5.6	..	..	29	4	30.7	..	..	0
	8	191	B.Ophi	6.3	5	22.4	—2.4	—2.4	133	6	26.9	—0.7	+0.3	232
	8	*b*	Ophi	4.3	6	4.2	—1.8	—1.6	111	7	17.2	—0.5	—0.5	251
	10	ψ	Sgtr	4.9	7	31.6	—1.5	—0.7	83	8	46.0	—0.5	—0.4	250
	13	154	B.Capr	6.1	3	36.1	—1.5	+1.5	71	4	59.5	—2.1	+1.2	252
	14	τ	Aqar	4.2	8	7.3	—3.0	—0.2	93	9	14.1	—0.6	+2.1	197
	18	64	Ceti	5.7	7	38.1	—1.7	+0.6	101	8	28.8	—0.2	+3.1	190
	18	ξ^1	Ceti	4.5	8	43.3	—2.5	+0.4	100	9	36.7	—0.2	+3.4	186
	20	43	Taur	5.7	12	30.4	—1.7	+2.1	45	13	49.6	—2.4	—0.3	268
	24	35	B.Canc	6.4	10	14.1	+0.4	+1.5	63	11	4.0	—0.5	+0.2	297

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

Asteroid Notes

By HUGH S. RICE

A combination of faintness of magnitude and cloudy weather at our station has interfered with the usual good observation of minor planets here this spring. The first three asteroids below are in very rich regions of the heavens, in the Milky Way, and Pallas also is in a good area.

IRIS, which has an average magnitude at opposition of 8.4, is assuming a maximum brightness at this apparition of only about 9.5, in early June. In July it is a 10th-magnitude object in Scorpius, close to the star Beta Scorpii. This feature of proximity to a bright star would make it very easy to locate with small telescopes, but the faintness works against it.

HERCULINA in July is east of Eta Ophiuchi, the magnitude being about 10 or somewhat fainter. In the second week of August it begins to go direct again. Observers desiring the planet's ephemeris may write to the author for same. The last sentence concerning IRIS applies here also. There is a great difference in ease of locating an asteroid, according to whether or not it is near any bright stars. In a comparatively starless region it may take a half-hour or more—especially at the first pick-up of the apparition—whereas if the planet is near a bright star, one can often find it at once.

VICTORIA is brighter than the above two asteroids, being about magnitude 9 in mid-July, when it is at the Scutum-Serpens Cauda boundary. In early August it goes direct again, and becomes half a magnitude fainter.

PALLAS is much farther north than the three planets just mentioned, and hence is better for northern observers. In the latter part of June and early July it is in eastern Hercules, at about magnitude 8.9. At the end of the ephemeris-time it is probably not fainter than 9.2. It should be good for small telescopes if the apparent path is plotted on a detailed star chart.

VESTA, the finest minor planet for observation, and the one on which we have noted a definite color, is beginning another apparition this summer—not far from the vernal equinox—and will last for the summer and autumn. It will be noticed that in our ephemeris the places are close together, being around the eastern stationary point, which is reached about August 12. Therefore the planet does not move much in several weeks. The stationary point is 6° east and 3° north of Iota Ceti. At the beginning of the ephemeris-time, VESTA is at magnitude 8.1,

but this goes to about 7.5 at the end of the period, and to magnitude 7.1 at opposition in September. Our magnitudes are all visual and are predicted on the basis of photo-magnitudes computed with the ephemeris, with a correction applied by us. The correction is on the basis of previously observed comparisons of visual and photo-magnitudes of the asteroid. This asteroid is usually good for work with field-glasses.

For the subjoined ephemerides we are indebted to Dr. Dirk Brouwer of the Yale University Observatory.

ASTEROID EPHEMERIDES

For 0^h U.T. Equinox 1946.0

7 IRIS

1946		α h m	δ ° ′
June	29	16 9.3	—21 38
July	4	16 6.2	—21 21
	9	16 3.6	—21 5
	14	16 1.8	—20 52
	19	16 0.6	—20 40
	24	16 0.1	—20 32
	29	16 0.3	—20 25
Aug.	3	16 1.1	—20 20
	8	16 2.5	—20 17

12 VICTORIA

1946		α h m	δ ° ′
June	29	18 30.9	—10 59
July	4	18 26.4	—10 31
	9	18 22.1	—10 8
	14	18 18.2	— 9 51
	19	18 14.8	— 9 38
	24	18 12.1	— 9 31
	29	18 10.2	— 9 29
Aug.	3	18 9.3	— 9 31
	8	18 9.2	— 9 36
	13	18 10.2	— 9 45
	18	18 12.0	— 9 56

2 PALLAS

1946		α h m	δ ° ′
June	29	18 21.0	+23 46
July	4	18 16.8	+23 30
	9	18 12.8	+23 7
	14	18 8.9	+22 38
	19	18 5.4	+22 2
	24	18 2.3	+21 21
	29	17 59.6	+20 35
Aug.	3	17 57.3	+19 45
	8	17 55.6	+18 52
	13	17 54.3	+17 56
	18	17 53.6	+16 58

4 VESTA

1946		α h m	δ ° ′
July	19	0 33.8	— 4 58
	23	0 35.9	— 5 4
	27	0 37.7	— 5 12
	31	0 39.1	— 5 23
Aug.	4	0 40.0	— 5 37
	8	0 40.5	— 5 53
	12	0 40.5	— 6 13
	16	0 40.2	— 6 35
	20	0 39.4	— 6 59

Hayden Planetarium, American Museum of Natural History,
New York, N. Y., May 23, 1946.

Comet Notes

By G. VAN BIESBROECK

The expected PERIODIC COMET TEMPEL II was recovered by the writer before dawn May 1. After several attempts failed to reveal its presence near the ephemeris position given by the British Computers (see p. 207) I received a much delayed letter by airmail dated February 20 from P. Ramensky, Harbin (Manchuria), giving the results of his extensive computations on this comet. By combining the three apparitions of 1920, 1925, and 1930 he obtained a reliable orbit. The object having been missed at the less favorable returns of 1935 and 1941 Ramensky had to compute the perturbations by all planets through the three revolutions since the last observations in 1930. During the most recent revolution the comet

approached Jupiter to within one astronomical unit for a period of 1½ years with a minimum separation of 0.63 on July 5, 1943. Perturbations were therefore large and they delayed perihelion by 70 days to 1946 July 2.2677. The night following receipt of this message being clear, I obtained with the 24-inch reflector of the Yerkes Observatory a very faint but definite image of the comet in the position:

1946 May 1.39345 $20^h\ 36^m\ 7^s.17$ $-9°\ 23'\ 59''.8$ (1946.0)

which differs by −15 sec. in right ascension and +0'.1 in declination from the computed location. A change of only 1.8 hours later in the time of perihelion would remove these residuals. This is a remarkably precise prediction after three unobserved returns.

The comet appeared as a small diffuse spot much fainter than was expected. On May 1 I estimated the magnitude as 17 but further estimations on May 5 and 8 indicated a rapid increase to magnitude 15. It seems therefore doubtful if the comet could have been discovered much earlier.

The following prediction of positions has been obtained by applying the small correction of the perihelion time to the ephemeris given by Ramensky:

EPHEMERIS OF COMET TEMPEL II (1950)

1946	α h m s	δ ° ′	Distance from Earth	Distance from Sun
June 5	22 23 37	−6 32.1	0.861	1.424
13	22 48 38	6 9.1	0.814	1.409
21	23 14 2	5 58.1	0.774	1.377
29	23 38 28	6 1.5	0.739	1.394
July 7	0 1 48	−6 21.1	0.710	1.395

Since the distances from both the earth and the sun are decreasing until July, the comet will brighten up but it will probably remain too faint for most ordinary telescopes.

COMET TIMMERS (1946*a*) has continued to describe its circumpolar course through April. It has shown some fluctuations in brightness; I estimated the magnitude as 10 on May 8. Slow decrease in brightness will now set in but the position will remain favorable for several months longer as shown by the following continuation of Cunningham's ephemeris:

1946		α h m	δ ° ′	Mag.
June	5	12 13	+82 56	10.0
	13	13 20	80 44	
	21	14 5	77 48	
	29	14 36	74 21	
July	7	15 0	70 29	10.6
	15	20	66 17	
	23	36	61 48	
	31	15 51	57 8	
Aug.	8	16 5	52 21	11.2
	16	18	47 34	
	24	30	42 51	
Sept.	1	16 42	+38 17	11.8

Two more periodic comets are expected in the morning sky: they are BROOKS' second and GIACOBINI-ZINNER'S, both of which will be favorably located later in the summer.

Williams Bay, Wis., May 10, 1946.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

While the American Meteor Society was originally founded with the expectation that its active membership probably would be limited to North America, almost immediately we had a few persons, living elsewhere, who desired to join and hence were most cordially welcomed. Some of these have made or are still making notable contributions to our work. European observers were, however, encouraged to join their national societies rather than the A.M.S., for very obvious reasons. One of the few exceptions was Eppe Loreta of Bologna, Italy, whose untimely death occurred on September 5, 1945, as announced in POPULAR ASTRONOMY for April. As one who had for many years, until stopped by war, corresponded regularly with this able and active observer, and had received long and valuable meteor reports from him, I should like here to say a few words in appreciation of his work.

In looking over my published annual reports, his name is found first in that covering 1933 and last in that covering 1940. During these eight years he sent in observations of 5032 meteors, perhaps half with complete coordinates and descriptions of their paths, magnitudes, and trains. His best year was 1936 when on 55 nights he observed 1438 meteors. Even more important were his careful reports on long-enduring meteor trains. For these he had the good judgment—which many of us do not have—to use a pair of binoculars in observing the changes of shape and direction of drifts. In my paper on this subject, *F. O. R.*, No. 60, out of a total of 1336 trains for all recorded time, Loreta should be credited with 23; 10 by name and 13 referred to as in the *Journal of the R. A. S of Canada*. Since the projected drifts could be derived in practically all these cases, his contribution was of extremely great value. Any work done by him since 1940 could not reach me, due to war, so this note perforce is limited to the years mentioned. In his death his country has lost perhaps its foremost amateur astronomer, the A.M.S. a loyal and skillful member, and meteoric astronomy in general one of its most efficient observers.

In another case, it is a pleasure to report that Korizo Komaki of Kanaya, Japan, who since 1937 had been an active member of the A.M.S., has survived the war. Further, I have been able to get hold of some of his recent work, published in Japan, where indeed he is president of the Meteor Section, O.A.A. Of even greater importance, I have secured copies of full reports, which were in his hands, of five long-enduring trains observed in his country, and also copies of routine A.M.S. observations made in the years 1941 and 1945. In the publication, which covers the work of their Meteor Section for 1942-45 inclusive, the most interesting item is that, on 1945 April 21/22, Komaki himself from $15^h:00$ to $16^h:07$, $F = 0.9$, observed 112 meteors, most (possibly all?) Lyrids. This again shows a sharp, brief maximum for these meteors such as was observed by Prof. H. N. Russell in Greece in 1922 (see *Pub. of Leander McCormick Observatory*, Vol. V, Part 1, page 17). No appreciable number of Lyrids were seen on any other night during their epoch for the four years covered in this report. The Japanese observers

seem among the few willing to brave the cold of the Quadrantid epoch. In 1942 January 3/4, T. Ishibashi, over a period of 2½ hours, observed 50 meteors, despite F being 0.6 only, and M. Tanaka, on the same night, observed 45 meteors in 2⅓ hours, F not given. In 1943 January 3/4, in 4¼ hours, F = 0.75, K. Saito observed 163 meteors; others also had good rates. In 1944 January 3/4, in 2⅔ hours, F = 0.6, 81 meteors were seen by Suzuki, while in 1945 one observer on January 2/3 and on January 4/5 had extremely low rates. Komaki secured good radiants for the Eta Aquarids in 1943 on May 6 and May 7. During the four years, 26 observers worked on 222 nights, recording a total of 3742 meteors. From these were determined 69 radiants, many referring to the principal showers. One may infer from this that the average plotting was of quite good quality. This Meteor Section report shows a most healthy interest in science, especially when we consider the local hardships due to continuous war. It seems to me that, if this group in Japan could do this much, despite the conditions which prevailed there, our own countrymen, who in the same period lived in safety and relative luxury, should have had a better record in meteor observing than was shown. Seeing what others do under difficulties should have the effect of stirring up our own energies and interests.

It is indeed perfectly clear that few persons have the time, opportunity, skill, and desire to become regular meteor observers. Any meteor association therefore must, to exist at all, welcome persons who can work but seldom and many whose interest is casual. All such can do and on occasion will do something which has real value. But to become an excellent observer, whose plotting permits the derivation of accurate radiants, demands considerable work over long periods of time. At present, few in the A.M.S. approximate to this class. This is partly due to many of our most active observers having been in service, or perhaps still being. But as peace conditions slowly revive, if the A.M.S. desires to compete with the work of the better British and Russian observers—and doubtless others—we must find persons whose interest in the subject will induce at least a few to make out some regular program and stick to it for a long time. In other words to make it a primary ambition to excel in this really important branch of observational astronomy. Those who live in parts of the country where the air is transparent and the number of clear nights is large would have a tremendous advantage. But nearly everyone has, at times, good nights for work, if only the interest is there. So while the A.M.S. has many fairly good observers, and 1945 furnished a gratifying total of meteors recorded, I would be wrong in not warning our members that most of them sadly need training in plotting and there is no way to get it but by spending long hours in actually doing it. If we could only induce some to work, for example, twice a month for 4-hour periods—and do it every month starting work not earlier than 11 P.M., by the end of a year we would begin to have a trained group whose plotting could be relied upon. Then we would derive good radiants and, for two groups working simultaneously, good heights. For a strong, ambitious young or middle-aged person, who does not have routine night work in an observatory, such a program should not be too exacting. Of course only nights which are very clear and without moonlight should be used. The writer would gladly outline a more specific program to anyone who feels he or she could devote this much time to meteoric astronomy. But please do not write unless you are serious about doing it!

As usual, for the period August 9-13, inclusive, when the Perseids are at their

maximum, the annual newspaper campaign is planned. This is the epoch when hourly counts are most needed and the general public is urged to volunteer their help. Members who will need maps, etc., are asked to write for them some weeks in advance and not wait until the last moment. Such requests should be here by August 1 to receive certain and prompt attention.

Recently I received a letter from Lieut. Commander Fletcher G. Watson enclosing one from Mr. W. F. Tyler of Mandeville, Jamaica, B.W.I., along with a reprint by the latter dealing with the Video meteorite of 1915 February 13. I actually was familiar with the case having run across it a couple of years ago in *The Journal of the North China Branch of the Royal Asiatic Society*, Vol. 46, 1915, which by good chance was found at the library of the American Philosophical Society here. As this journal is doubtless rare in America, Mr. Tyler feels that it is probable his paper was known to few and the important points unknown to many interested in meteors. With this in view a very brief résumé will be given: those interested further should seek the original. It should be stated that Mr. Tyler was then stationed in or near Shanghai, China, and made several personal trips to interview witnesses on the islands, both Chinese and European, so his results had this great advantage. His investigation seems very thorough.

The time was 11:49 A.M., 1915 February 13 and the fireball was over the Chusan Archipelago. Two maps give the path: measuring therefrom the distance from projected beginning point to point where it fell is about 100 km, but as there is a strongly curved path, convex to the west for the last one-third, the projected distance is considerably greater. The direction of travel for the first two-thirds was about to 15° W of S, for actual end element 40° E of S. It fell into the sea some 6 or 8 km south of Video Island, so there was no chance for recovery. The object was very brilliant, of an irregular shape like a boomerang—which doubtless accounted for the curved path—and very violent sound phenomena were heard shortly after its disappearance. It left a smoke-train, but this latter is not clearly described as to either duration or drift, but it must have lasted some time. The best observation seems to have been from Steep Island, 16 km N.W. of Video, and it was there reported to have been so low that it was expected that the lighthouse tower would be struck. Its dimensions there were estimated as being 5 by 20 feet. Mr. Tyler, using other estimates, feels that its true dimensions were much larger, perhaps, as much as 80 feet in diameter. This is the only point on which the reviewer must take absolute exception, as to the rest he is quite willing to accept Mr. Tyler's opinion. For had the body been so large the results on striking the water would have been, I believe, very serious, for such a large solid body should have been carrying an immensely compressed air-cap. (Compare what happened in Siberia on 1908 June 30.) Also we know that all meteoric bodies *look* larger than their true dimensions. But the case is most interesting in that we have eye-witness accounts of the fall of a meteorite into the sea, and a body which seems to have radically changed the azimuth of its path. I have seen this happen for small meteors but never worked out a fireball path for which it could be proved. The rough coordinates of the radiant were $h = 25°$, $a = 195°$.

Flower Observatory, Upper Darby, Pa., 1946 May 13.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
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The Abundance of the Chemical Elements in Meteorites and Tektites

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ABSTRACT AND INTRODUCTION

In an earlier note (*C.S.R.M., P.A.*, **54**, 152, March, 1946) I have listed the 5 elements that so far have not been found in meteorites, with the comment that they are all very rare on Earth and that a similar rarity in meteorites may account for their apparent absence. In this paper I shall list not only the elements that *do* occur in meteorites but also, insofar as possible, their relative abundance. Since we have no very accurate knowledge of the relative proportions of aerolites and siderites, it will be necessary to list those two kinds of meteorites separately; similarly, the abundance of troilite in meteorites is uncertain; moreover, certain elements seem to be concentrated in troilite; therefore, it is instructive to list also that material separately. Little or no work has been done on the abundance of the elements in any other meteoritic mineral; so no others need be listed. Tektites are not certainly meteoritic, but even if they be, they are so completely different from the siliceous meteorites that they, too, deserve a separate listing.

In Table 1, the figures for the abundance of the elements in meteorites and in troilite are based on a table in Mellor's work,[1] but he credits the data to the Noddacks.[2] I have attempted to bring that table up to date. von Hevesy gives a similar, but less complete, list,[3] which he attributes to "the work of Goldschmidt[4] and especially to Walter and Ida Noddack."[5] The figures for the tektites are the results of my own calculations, based principally on a compilation of analyses by Barnes.[6] I have, however, used 10 other analyses that are not found in his work; on the other hand, I have not included analyses of Darwin glass, because it is almost certainly *not* tektitic. I have not included also analyses for schonite, South American "tektites," and Libyan glass, because there is a reasonable doubt that these materials are really tektites; as a matter of fact, with the exception of the elements Si and O, it makes little difference whether these substances are included or not. When there are sufficient analytical data, a definite figure is given for tektites. When there are not sufficient data, the element is listed merely as "present." A question mark indicates that the element in question has been reported chemically only once. It should be remembered that the fact that an element is not often reported does not mean that it is usually absent; it may mean simply that the element is seldom looked for. "Spectroscopic" means that the element has been reported with the aid of a spectroscope, but not chemically.

TABLE 1

THE ABUNDANCE OF THE CHEMICAL ELEMENTS IN METEORITES ETC.*

Atomic No.	Name and Symbol	Aerolites (A)	Siderites (Si)	Troilite	Tektites (T)
1	Hydrogen, H	Present	Present		Present
2	Helium, He	Present	Present	Present	Present
3	Lithium, Li	5.0×10^{-6}	Present?		Present
4	Beryllium, Be	1.0×10^{-5}	Present		Spectroscopic
5	Boron, B	0	Present		Spectroscopic
6	Carbon, C	3.4×10^{-4}	3.9×10^{-4}		Present
7	Nitrogen, N	Present	1.0×10^{-5}		Present
8	Oxygen, O	4.204×10^{-1}	Present		4.93×10^{-1}
9	Fluorine, F	Present			
10	Neon, Ne	Present?			Present
11	Sodium, Na	7.18×10^{-3}			1.01×10^{-2}
12	Magnesium, Mg	1.590×10^{-1}	3.2×10^{-4}		1.27×10^{-2}
13	Aluminum, Al	1.61×10^{-2}	4.0×10^{-5}		6.72×10^{-2}
14	Silicon, Si	2.143×10^{-1}	8.0×10^{-3}		3.396×10^{-1}
15	Phosphorus, P	5.06×10^{-4}	1.47×10^{-3}	3.05×10^{-3}	3.4×10^{-4}
16	Sulfur, S	2.01×10^{-2}	3.6×10^{-4}	3.43×10^{-1}	Present?
17	Chlorine, Cl	9.04×10^{-4}	Present		Present
18	Argon, A		Present?		Present
19	Potassium, K	2.63×10^{-3}			2.07×10^{-2}
20	Calcium,Ca	1.92×10^{-2}	5.0×10^{-4}		1.74×10^{-2}
21	Scandium, Sc	1.1×10^{-4}	Present		Present?
22	Titanium, Ti	2.10×10^{-3}	4.0×10^{-5}		7.1×10^{-3}
23	Vanadium, V	3.0×10^{-4}	6.2×10^{-6}	4.5×10^{-5}	Spectroscopic
24	Chromium, Cr	5.0×10^{-3}	2.4×10^{-4}	1.20×10^{-3}	5.5×10^{-5}
25	Manganese, Mn	2.05×10^{-3}	3.0×10^{-4}	4.6×10^{-4}	9.3×10^{-4}
26	Iron, Fe	1.276×10^{-1}	9.02×10^{-1}	6.11×10^{-1}	3.06×10^{-2}
27	Cobalt, Co	1.81×10^{-4}	5.47×10^{-3}	2.08×10^{-3}	
28	Nickel, Ni	2.01×10^{-3}	8.46×10^{-2}	2.88×10^{-2}	3.1×10^{-5}
29	Copper, Cu	1.55×10^{-6}	3.05×10^{-4}	4.20×10^{-3}	Present
30	Zinc, Zn	3.40×10^{-6}	1.15×10^{-4}	1.53×10^{-3}	
31	Gallium, Ga	5×10^{-6}	1.3×10^{-5}	Present	Present
32	Germanium, Ge	3.3×10^{-5}	2.36×10^{-4}	1.5×10^{-3}	Present?
33	Arsenic, As	2.0×10^{-5}	3.6×10^{-4}	1.02×10^{-3}	
34	Selenium, Se	Present	Present	8.4×10^{-4}	Spectroscopic
35	Bromine, Br	1.0×10^{-6}			
36	Krypton, Kr				
37	Rubidium, Rb	4.5×10^{-6}	0	0	
38	Strontium, Sr	7.2×10^{-5}	Present		Spectroscopic
39	Yttrium, Y	3.4×10^{-5}	Present		Present?
40	Zirconium, Zr	1.0×10^{-4}	8.0×10^{-6}		Present
41	Columbium, Cb	2.0×10^{-6}	1.0×10^{-6}		
42	Molybdenum, Mo	2.5×10^{-6}	1.66×10^{-5}	1.10×10^{-5}	
43	Masurium, Ma		Present	Present	
44	Ruthenium, Ru	0	2.39×10^{-5}	4.20×10^{-6}	
45	Rhodium, Rh	0	5.0×10^{-6}	1.0×10^{-6}	
46	Palladium, Pd	0	1.9×10^{-5}	4.5×10^{-6}	
47	Silver, Ag	0	3.2×10^{-6}	2.1×10^{-5}	
48	Cadmium, Cd		8.0×10^{-6}	3.0×10^{-5}	
49	Indium, In		Present	8.0×10^{-7}	
50	Tin, Sn	4.0×10^{-6}	1.02×10^{-4}	1.61×10^{-3}	Spectroscopic
51	Antimony, Sb	1.0×10^{-7}	2.0×10^{-6}	7.8×10^{-6}	
52	Tellurium, Te			1.7×10^{-5}	
53	Iodine, I	Present	Present		
54	Xenon, Xe				
55	Caesium, Cs	1.0×10^{-7}			

TABLE 1 (CONTD.)

Atomic No.	Name and Symbol	Aerolites (A)	Siderites (Si)	Troilite	Tektites (T)
56	Barium, Ba	2.0×10^{-5}	Present		1.8×10^{-5}
57	Lanthanum, La	Present			
58	Cerium, Ce	4.0×10^{-6}	Present		
59	Praseodymium, Pr	Present			
60	Neodymium, Nd	3.0×10^{-6}			
61	Illinium, Il				
62	Samarium, Sm	3.0×10^{-6}			
63	Europium, Eu	Present			
64	Gadolinium, Gd	Present	Present		
65	Terbium, Tb	Present			
66	Dysprosium, Dy	Present			
67	Holmium, Ho	Present			
68	Erbium, Er	Present			
69	Thulium, Tm	Present			
70	Ytterbium, Yb	Present			
71	Lutecium, Lu	Present			
72	Hafnium, Hf	1.0×10^{-6}	Present		
73	Tantalum, Ta	7.0×10^{-7}	1.0×10^{-6}		
74	Tungsten, W	1.8×10^{-5}	8.1×10^{-6}	Present	
75	Rhenium, Re	8.0×10^{-10}	8.2×10^{-9}	1.0×10^{-9}	
76	Osmium, Os		8.8×10^{-6}	1.0×10^{-5}	
77	Iridium, Ir	0	2.3×10^{-6}	5.0×10^{-7}	
78	Platinum, Pt	8.3×10^{-8}	1.77×10^{-5}	3.0×10^{-6}	
79	Gold, Au	Present	1.4×10^{-6}	4.5×10^{-7}	
80	Mercury, Hg			Present	
81	Thallium, Tl		Present	3.0×10^{-7}	
82	Lead, Pb	5.0×10^{-6}	5.3×10^{-5}	7.1×10^{-4}	Spectroscopic
83	Bismuth, Bi		5.0×10^{-7}	2.0×10^{-6}	
84	Polonium, Po	1×10^{-16}	8×10^{-18}		Present
85	Alabamine, Ab				
86	Radon, Rn	2×10^{-18}	1×10^{-19}		Present
87	Virginium, Vi				
88	Radium, Ra	4×10^{-13}	3×10^{-14}		9.5×10^{-11}
89	Actinium, Ac	9×10^{-17}	7×10^{-18}		Present
90	Thorium, Th	2.0×10^{-6}	Present		1.3×10^{-5}
91	Protoactinium, Pa	3×10^{-14}	5×10^{-15}		Present
92	Uranium, U	1×10^{-6}	1×10^{-7}		Present

NOTE TO TABLE 1

*All the quantities listed in this table are given in terms of gram per gram (g./g.).

Both hydrogen and helium are present in meteorites as well as in tektites. In the latter case, the helium is possibly derived, wholly or in part, from the Earth's atmosphere. The same remark applies also to stone meteorites (aerolites). The average of a large number of determinations of helium in siderites is 10.97×10^{-6} cc./g., but this element varies widely, and appears to be derived wholly from radioactive disintegrations.

Neon was first reported in aerolites by myself, with the comment that it may have been derived from the atmosphere.[7] I have since found it in several other aerolites. It has been reported likewise in moldavites (2.0 to 5.0×10^{-6} cc./g.).[8]

Argon has been reported in a Staunton, Virginia, siderite by Ramsay,[9] but I have been unable to detect it in the gases of several stone meteorites.[7]

Selenium has been detected chemically in both aerolites and siderites, but is more abundant in the former. In many of the latter it is reported to be absent.[10]

All of the halogens seem to be present in meteorites. Shannon and Larsen[11] were unable to detect fluorine, however, in the chlorapatite found in the aerolites of New Concord, Ohio. According to von Fellenberg,[12] the maximum bromine content of 9 aerolites examined by him was 5.6×10^{-7} g./g., which is much less than the quantity listed in Table 1. von Fellenberg reported also minute amounts of iodine in both aerolites and siderites; average $= 1.1 \times 10^{-5}$ g./g.

Uranium and thorium, as well as the other radioactive disintegration products, have been calculated from the radon and thoron contents of meteorites. These can be measured only because of their radioactivity, and, altho radon and thoron are isotopes, their separate radioactivities can be distinguished because of their different half-lives. I have indicated elements 84, 86, and 88-92 as present in tektites on the strength of the thorium and radium reported by Dubey.[13]

This study leaves as the only elements not yet found in meteorites the 5 following: krypton, xenon, illinium, alabamine, and virginium; only 67, or about two-thirds, of the 92 known elements, are present in known quantities, however.

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ADDENDUM

Since writing the foregoing paper, it has come to my attention that G. T. Seaborg and M. L. Perlman (see W. D. Harkins, *Science*, **103**, 299, 1946) find minute quantities of plutonium (Pu, atomic number 94) in pitchblende. If this arises from the action of stray neutrons on uranium, it follows that neptunium (Np, atomic number 93) also is temporarily present, altho its short half-life would make its demonstration well-nigh impossible. If these findings are correct, it follows that these 2 elements must be added to the list of known natural elements not yet found in meteorites. We should perhaps add likewise elements 95 and 96, recently produced (G. T. Seaborg and J. G. Hamilton, *Science*, **102**, 556, 1945) from uranium and plutonium. It is probable that these 4 elements (Pu, Np, 95, and 96) are, to all intents and purposes, *absent* from meteorites.

The protoactinium content of meteorites, as listed in Table 1, is calculated from the uranium content. The only actual measurement is the $0.035 \pm 0.011 \times 10^{-12}$ g./g., found in aerolites of Pultusk, Warsaw, Poland (R. D. Evans, Jane L. Hastings, and W. C. Schumb, *Jour. Am. Chem. Soc.*, **61**, 3451-5, 1939).

A Decisive Test for the Presence of even a Highly Rarefied Lunar Atmosphere

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From the phenomena of occultations it is generally agreed that there is hardly any atmosphere on the Moon. Whatever atmosphere it once had, it must have lost long ago, on account of its low surface gravity and consequent low velocity of escape. Nevertheless, several astronomers, such as W. H. Pickering, A. C. D. Crommelin, and Lincoln La Paz,[1] have thought, or still think, that the Moon is not completely devoid of a very tenuous atmosphere. A paper by Walter H. Haas, "Concerning Possible Lunar Meteoric Phenomena,"[2] has drawn further attention to the subject, and the present writer, in his article entitled, "The Old Moon in the Arms of the New,"[3] has pointed out the advantage of watching for variations in the intensity of the lunar earthshine and correlating them with meteoritic activity (especially with meteoric showers) here on the Earth.

If there be any appreciable atmosphere on the Moon, on account of its very tenuity it would give rise to auroral phenomena over that portion of the lunar surface that is lighted up by earthshine. While it would be too much to expect direct observational evidence of auroral curtains, coronas, and streamers, the usual auroral lines, *viz.*, the green one at λ 5577.3, due to a forbidden transition in neutral oxygen atoms; the red ones at λλ 6300.2 and 6363.9, also due to forbidden transitions in neutral oxygen atoms; and the more conspicuous negative bands, at λλ 3903.5, 3914.4, 4267.6, and 4708.7, due to ionized nitrogen molecules, *may* reveal themselves in the spectrum of the lunar earthshine—especially the two *red* lines, which are enhanced in the sunlight-type of aurora, seen from high terrestrial latitudes. Comparison with the spectra of neighboring portions of the sky should eliminate the effects of auroral activity in the Earth's atmosphere.

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1946 February 16

Comments on the Preceding Paper by Professor M. A. R. Khan

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ABSTRACT

This communication presents comments on Professor M. A. R. Khan's paper concerning the possibility of detecting the strongest radiations of terrestrial polar auroras in the spectrum of the earthshine. It also suggests the desirability of photographing the Moon in infra-red radiation corresponding to the O-O band of the first positive system of N_2. The possibility of extending Professor Khan's proposal by studying the lunar ionosphere and by studying other phenomena suggested by known solar-terrestrial relationships is briefly discussed.

Thru the kindness of Professor F. C. Leonard, I have been allowed to read Professor M. A. R. Khan's interesting paper prior to its publication. The follow-

ing remarks are extensions of Professor Khan's proposal, and it is probable that many of these ideas have already occurred to him. It is not clear to me whether Professor Khan proposes the observation of polar or non-polar auroras on the Moon, altho his reference to the strong negative system of N_2^+ would imply that he is talking about polar auroras. It also seems to be implied by Professor Khan that the lunar aurora is excited by solar radiation that reaches the Moon by way of the Earth. It is difficult to see how this occurrence could take place, because the Earth's atmosphere would filter out all of the short-wave radiation that is capable of exciting any kind of aurora.

The spectra of lunar auroras should resemble those of the terrestrial auroras very closely. Terrestrial auroras are classified into 2 general types, polar and non-polar. The polar auroras are the so-called aurora borealis and aurora australis, and the non-polar aurora is that portion of the light of the night sky that originates in the Earth's upper atmosphere. If we assume that the Moon possesses a magnetic field similar to that of the Earth, then there should be polar auroras on the Moon. Even in the absence of a lunar magnetic field, the Moon's atmosphere should radiate after sunset on the Moon in a manner similar to that of the terrestrial non-polar aurora.

The principal radiations in the spectrum of the non-polar aurora of the Earth are the forbidden lines of atomic oxygen and the Vegard-Kaplan bands of molecular nitrogen. Laboratory studies by myself have shown that auroral afterglows exist at pressures that fall in the range from 10^{-3} mm. Hg to 100 mm. and that the spectra of these afterglows consist principally of the most intense radiations of the non-polar aurora. It is likely that these statements would apply to afterglows at pressures higher than 100 mm. It is reasonable, therefore, to predict that the spectrum of a lunar non-polar aurora would be like that of one on the Earth and that this spectrum would be independent of pressures in its main features.

In considering the possibility of the existence of lunar auroras, one must call attention to the "auroral flash" that was first reported by V. M. Slipher of the Lowell Observatory in 1933. This flash is observed during twilight and just preceding astronomical dawn, and its spectrum resembles that of a polar aurora in a most remarkable manner. The principal difference between the spectrum of the auroral flash and that of the non-polar aurora is the absence from the latter of the negative system of N_2^+, the members of which are strong in the spectra of polar auroras. It is likely, therefore, that one would not find these bands under the conditions proposed by Professor Khan, unless a lunar polar aurora occurred during the exposure. On the other hand, the forbidden lines of oxygen are strong in all auroras, and these should be observable at all times during a lunar night, provided, of course, that the light of the Earth's line does not interfere.

It seems to be clear from photometric studies of the non-polar aurora that only a very small part of the energy of the upper atmosphere is lost by radiation during the night. It is possible, therefore, that the light of the lunar non-polar aurora would remain fairly constant in intensity and in quality during the long lunar night. This circumstance should make it possible to make an extended exposure on the lunar non-polar aurora. It would be difficult, however, to distinguish between the spectrum of the lunar non-polar aurora and that of the Earth, unless changes in relative intensities, due to differences between the lunar and terrestrial atmospheres, occur. Laboratory investigations indicate that such in-

tensity changes might occur, and that these differences might be enhanced by the meteoritic dust in the lunar atmosphere. Meteoritic dust would undoubtedly encourage the recombination of atomic oxygen and atomic nitrogen, and, in the latter case, this would result in an increase in the intensities of the Vegard-Kaplan bands. Some unpublished results of laboratory investigations by myself have shown a strong correlation of the intensities of the Vegard-Kaplan bands with the recombination of atomic nitrogen. These bands are relatively weak in terrestrial auroras, and their enhancement in lunar auroras would be an important and clear phenomenon.

The mechanism that is most attractive in accounting for the close relationship between the intensities of the Vegard-Kaplan bands and the recombination of atomic nitrogen calls for the emission of the O-O band of the first positive system of N_2. This fact is based on the remarkable coincidence between the energy of dissociation of the nitrogen molecule and the energy that is necessary to produce a nitrogen molecule in the zeroth vibrational state of the electronic level, on which the first positive bands originate. The wavelength of the O-O band is about 1.05 μ; so a photograph of the Moon, made with the aid of an infra-red filter and the available infra-red-sensitive plates, might reveal an occasional enhancement of this effect. This technique would have an advantage over spectroscopic observations, since shorter exposure times would undoubtedly be effective. Simultaneous observations should be made on the Moon and on the neighboring portions of the sky.

It would be interesting to extend Professor Khan's ideas and to speculate about the existence of a lunar ionosphere and the role that it might play in the reflection of radio waves originating on the Earth. The approach to this problem might be an attempt to detect differences between nighttime and daytime reflections from the Moon. There should be also some correlation between the phenomena of the lunar atmosphere and the various solar phenomena that have been related to terrestrial atmospheric occurrences; among these might be mentioned sunspots and chromospheric eruptions. Professor Khan's short note should encourage study and speculation concerning the possible phenomena of the atmospheres of planets as well as that of the Moon.

The excellent summary by C. T. Elvey in Vol. 14 (1942) of the *Reviews of Modern Physics* will give the reader the background necessary for the understanding of the principal details of auroral spectra. The suggestion that the reader refer to this review is presented in lieu of an extended list of references.

Interplanetary Meteorites and Minor Planets

A "meteorite in space" has been defined as "a solid body of subplanetary dimensions existing as a discrete unit in space."[1] The question has been raised as to when such a mass in interplanetary space—revolving primarily around the Sun—should be regarded as a meteorite and when it should be considered a minor planet. The question is of academic interest only, for the distinction to be made between the largest interplanetary meteorite on the one hand and the smallest minor planet on the other depends simply upon what is meant by "subplanetary dimensions"—and that, in turn, is a matter merely of definition; it is quite likely that, as concerns size at least, interplanetary meteorites and minor planets together represent a perfect gradation of astronomical bodies.

A practically useful criterion for discriminating between interplanetary

meteorites and minor planets, recently proposed in conversation by my colleague, Dr. Samuel Herrick, is that, if the body in interplanetary space is *individually* observable, either visually or photographically, it should be regarded as a minor planet, while, if it is not so detectable, it should be called an interplanetary meteorite. Obviously, in accordance with this criterion, as the power of telescopes and cameras increases, more and more interplanetary bodies will be brought to light as minor planets, whereas fewer and fewer of them will continue to be classifiable as interplanetary meteorites.

Probably those small solid bodies that (1) compose the rings of Saturn[2]; (2) produce the zodiacal light and the counterglow; (3) revolve around the Sun in swarms; and (4) are a constituent part of comets, are destined never to be separately discernible, and so will always be appropriately termed "meteorites in interplanetary space." F.C.L.

[1] Leonard, F. C., "Working Definitions of Fundamental Terms in Meteoritics," *C.S.R.M.*, **3**, 201-2; *P. A.*, **53**, 244-5, 1945.

[2] The so-called "particles" that form the rings of Saturn are evidently of the nature of miniature satellites rather than diminutive planets, but this fact makes no difference, insofar as the present discussion is concerned.

Extrasolar or Interstellar Meteorites

On p. 461 of Russell, Dugan, and Stewart's *Astronomy*, **1**, Rev. Ed., 1945, it is stated that—

"The isolated bright meteor[ite]s, whose orbits have been accurately determined from photographs, have pursued direct orbits of fairly short period and are comparable to asteroids.

"Of the fainter meteor[ite]s, for which only much rougher visual data are available, about a third appear to have less than the [heliocentric] parabolic velocity and to be members of our [solar] system—'solar meteor[ite]s,' as Öpik calls them. The rest must be 'cosmic meteor[ite]s,' visitors from interstellar space, where it is now known that very thinly scattered particles exist (Chap. XXIV)."

Would not "extrasolar" or "interstellar meteorites" be a better term than "cosmic meteorites," since, regardless of where they originate or whence they come, *all* meteorites are "cosmic"? F.C.L.

Preliminary Notice of the Ninth Meeting of the Society

The Executive Committee of the Council hereby announces that, subject to the approval of the Council as a whole, the Ninth Meeting of the Society will be held on Monday and Tuesday, September 9 and 10, 1946, at Flagstaff, Arizona, and at the Canyon Diablo Meteorite Crater. The headquarters of the meeting will be probably at the Arizona State College in Flagstaff, and, if so, the meeting will open there at 9 o'clock on Monday morning, September 9. It is planned to hold the September 9 sessions in Flagstaff and those of September 10 at the Crater. Members of the Society are invited to send the Secretary, at their earliest opportunity, the titles and abstracts of any papers that they may wish to present at the meeting.

Since the Ninth Meeting will be an electoral meeting, the attention of members is directed to Art. 3, Sect. 3, of the Constitution of the Society (*C.S.R.M.*, **2**, 323-4, 1941) concerning the nomination of candidates for election. In accordance

with Art. 3, Sect. 5, of the Constitution (*loc. cit.*, p. 324), the Executive Committee is recommending to the Council that 3 Vice-Presidents and both a Secretary and a Treasurer be elected for the 1946-50 term. All the present Officers of the Society, except the President, are eligible for reëlection to the offices they now hold, altho the undersigned wishes to retire from the secretaryship at the end of the current term; both a new President and a new Secretary should therefore be nominated for election at the Ninth Meeting. All the present Councilors likewise are eligible for reëlection as Councilors, except Councilor (Ex-President) H. H. Nininger, who is ineligible for reëlection *as a Councilor*.

This will be the first meeting of the Society to be called since the end of the war. The last meeting, also held in Flagstaff and at the Crater, occurred on June 23, 24, and 25, 1941.

C. H. CLEMINSHAW, *Secretary*

President of the Society: LINCOLN LA PAZ, Department of Mathematics and Institute of Meteoritics, University of New Mexico, Albuquerque
Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, P. O. Box 9866, Los Feliz Station, Los Angeles 27, California

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By **LEON CAMPBELL, Recorder**

The 1946 AAVSO Spring Meeting: The first post-war spring meeting of the American Association of Variable Star Observers was held at the Smith College Observatory, Northampton, Mass., on May 3 and 4. Members began to arrive by mid-afternon on Friday, from as far as Toronto, Canada, in the north, and Oshkosh, Wisconsin, in the west. Maine, New Jersey, New York, Vermont, and Connecticut were well represented, with, of course, a large contingent from Massachusetts. Some sixty members and guests were present in the lobby of the Hotel Northampton in a sort of social hour, meeting friends, and discussing topics of mutual interest. On Friday evening the Council met for the transaction of necessary business, including the election of one Honorary member, Mr. Reginald P. de Kock of Capetown, South Africa; one Patron, Mr. Neal J. Heines of Paterson, New Jersey; five life members; and twenty-eight annual members; the largest group elected at any one meeting in many years. Perhaps the newspaper articles announcing the imminent attainment of the 1,000,000th observation had much to do with the increase in the number of candidates presented. Four foreign countries were represented, as well as fourteen different states in this country. Members were listed from Lima, Peru, and Lima, Ohio. The Council voted to make a token donation to the Henry Norris Russell Foundation, particularly appropriate in view of the fact that Professor Russell has been, for many years, one of our distinguished honorary members.

Considerable discussion arose in the Council over the matter of the number of persons to be included on the slate for Councilors, to be voted upon at the Annual meeting. It was finally decided to accept the slate of six candidates offered by the Nominating Committee, four of whom are to be elected. These include

Messrs. Nadeau, Treadwell, Mrs. Federer, Messrs. Parks and Sill, and Miss Stahr.

The gift to the Association of a fully-equipped three-inch refractor by Mr. Heines was announced, also a New Year's token gift from Mrs. Phoebe Haas.

The Council approved the Recorder's suggestion to present a suitably inscribed scroll to the member who had contributed the millionth observation.

At an adjourned meeting of the Council, the report of the Committee on Revision of the Constitution and By-Laws was accepted. These revisions and amendments, of a minor nature and affecting the more recent activities of the Association, will be voted upon at the Annual meeting.

Miss Dorrit Hoffleit was appointed Variable Commentator.

While the Council was in session, other members and guests had the opportunity to inspect the well-equipped observatory, and under ideal sky conditions, of observing with the 6-inch and 11-inch telescopes.

Saturday morning found the members gathered together for the regular business meeting. Professor Marjorie Williams, the Director of the Observatory, made us most welcome, and with the assistance of her colleague, Miss Jocelyn Gill, extended every facility of the observatory to make our meeting a real success. President Smiley presided, and first requested that those in attendance stand for a moment while the names of three former members who had died since the last meeting were announced. These were Professor A. Bemporad and Dr. Eppe Loreta of Italy, and Sr. Augusto Maupomé of Mexcoac, Mexico.

The proposed amendment to the by-laws relative to the increase in dues was read and accepted by the members. Henceforth, annual dues will be $3.00, sustaining dues, $10.00, and life membership fees, on an actuarial basis, ranging from $50.00 down to $15.00. In other words, the older one is upon application, the less he pays.

It was voted to send a message of greeting to our Patron and Life member, Mr. David B. Pickering, who, because of illness, was unable to be present.

Since the year 1946 marks the sixtieth anniversary of the founding of the Smith College Observatory, Dr. Williams took the occasion to give us an interesting account of its history, tracing its early development and its progress under the several noted directors, including Professors Byrd and Bigelow. Dr. Williams also mentioned the proposed plans for a new site for the observatory, atop the new science building, where better arrangements can be made for the class rooms and research laboratories.

Mr. Rosebrugh presented an account of his last winter's work, in cooperation with Secretary Harris, on detailed observations of the surface of Mars. He also referred to his drawing of the February sun-spot and the follow-up auroral display. Mr. Fernald, our ace observer from Wilton, Maine, discussed the advantages of polaroid filters in connection with observations of sun and moon. He also made an appeal, on behalf of the American Meteor Society, for the recording of telescopic meteors which may pass through the field of the telescope while one is observing variables.

A paper communicated by Mr. Paul A. Nadeau, of Quebec, Canada, was read by Mr. Heines, indicating that in the author's opinion there appears to be a definite relation between sun-spot cycles and the weather.

Following noon adjournment, the group posed for a professional photograph—ably assisted by our president, who took some snapshots in color.

Everyone gathered at the noonday luncheon in anticipation of the reported announcement concerning the millionth observation, which, to all but a selected few, had been kept a dark secret. While the meal was in progress, much speculation was rife as to who had contributed that particular observation. After coffee and ice cream had been disposed of, the Recorder was asked to read his paper, "Reaching for the One Million Mark" (printed in full in the May issue of POPULAR ASTRONOMY). After recounting the steps which had led to the goal of one million over the past thirty-five years, and with all ears awaiting the long-expected announcement, the name of Dr. William L. Holt was given as the one who had actually communicated the millionth estimate. The announcement met with high approbation, especially since Dr. Holt was present. Probably no one was more surprised and pleased than was the Doctor, unless it was Mrs. Holt.

President Smiley then presented Dr. Holt with the special scroll which had been inscribed by Mr. Fred E. Jones, adding that he hoped many of us would be present when the second millionth observation would be announced, perhaps at the end of the next twenty or twenty-five years.

The final session was called to order at 3:00 P.M., during which several more papers were offered; curiously enough, not one on variable stars.

Mr. Heines read a paper offered by Mr. F. J. Ryder on Levels of Lakes in Minnesota, in which the author showed the apparent correlation between sun-spot activity and lake levels in that state; a maximum in sun-spot area tending to produce maximum precipitation, with attendant high lake levels and cooler weather. Mr. Heines also referred to the sun-spot of last February, and a comparison of sun-spots during 1943 and 1944. The matter of bird migration as a profitable field of investigation was also mentioned by him.

Mr. Heines' own report of the work of the Solar Division of the AAVSO was read in part; he stressed the value of such work, in particular to the Department of Terrestrial Magnetism of the Carnegie Institution. In this report mention was also made of the work of Dr. J. C. Bartlett on fluctuations of granulation on the sun's surface.

Finally, the President read a letter from Walter Houston relative to telescope making and the use of such telescopes. Dr. Smiley closed by making an appeal for more amateurs to put to practical use their own telescopes, or seeing to it that such telescopes were put into the hands of those who, although they might not be able to build them, could use them to good advantage.

The meetings adjourned at 4 o'clock to convene again at Harvard in October.

Notes on Special Variables: Nova (T) Coronae Borealis, 155526, which made its second observed spectacular outburst in February last, has reached its normal pre-outburst visual magnitude, around 9.8. This stage was reached about a month after discovery by Deutsch. The star is being closely watched to note the possibility of a secondary increase in light, such as prevailed some three months after the maximum of 1866.

Nova (RS) Ophiuchi, 1744o6, although lacking definite observations during last December and January, may have had another secondary maximum early in this year. The star attained magnitude 9.8 in November, and from February to the present time has decreased from 9.6 to 11.6. Such anomalous behavior is not unprecedented in this recurrent nova.

T Orionis, 0530o5a, probably one of the most difficult of the irregular variables to observe because it is imbedded in the Great Orion Nebula, appears to

have undergone a short-lived drop to minimum at the 12th magnitude about March 30.

R. Leonis, 094211, is on its way to maximum—naked eye visibility—in June, and should be well observed at that phase.

Chi Cygni, 194632, is at maximum, magnitude 4.4, with evidence of a standstill having occurred on the increasing branch of the light curve.

R Hydrae, 1324*22*, the long-period variable with the well authenticated decrease in period over the centuries, from 500 to 400 days, is now at maximum, magnitude 5.0. The interval between the last three observed maxima averages 385 days.

Z Andromedae, 232848, is slightly fainter than the 10th magnitude, perhaps at one of its minima, following a maximum at 9th magnitude in March, 1945.

U Geminorum, 074922, was observed at maximum by several AAVSO members late in April, six months after a wide maximum was last observed.

SS Cygni, 213843, has had three well-observed maxima so far this year; maximum 350 on January 1, of the wide type; maximum 351, late in that same month, of the anomalous type; and maximum 352 about April 10, of the wide type, seventy days later.

R Coronae Borealis, 154428, is back at normal maximum brightness, magnitude 6.0, but one cannot assume that it will remain for long at that stage.

SU Tauri, 054319, after passing through a sharp decrease in light of about a magnitude in February, is again back to normal brightness. S Apodis, 1459*71*, and RY Sagittarii, 1910*33*, have also reached full maximum brightness.

Z Camelopardalis, 081473, has presented five well-observed maxima since January first, at intervals of almost exactly a month each, with an average range of nearly three magnitudes.

Observations for March and April: A total of 6,747 observations—2,860 in March and 3,887 in April—were contributed by 66 observers, as listed herewith:

Observer	March—1946—April No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	March—1946—April No. Var.	No. Ests.	No. Var.	No. Ests.
Adamopoulos	50	90	..	..	Holt	121	223	130	381
Ashbrook	9	28	3	14	Howarth	14	15	17	17
Bappu, M. K. V.	..	..	20	69	Hukill	3	34	3	26
Bappu, M. K.	..	..	28	89	Irland	22	22	..	..
Blunck	25	27	9	11	Itzigsohn	55	318	..	..
Boone	3	3	10	10	Joerg	..	..	7	7
Bouton	8	11	25	36	Kearons	23	23	10	10
Braitberg	12	33	9	33	Kelly	10	14	13	13
Buckstaff	9	14	..	..	Kitley	26	47	35	64
Cameron	..	..	8	8	de Kock	66	207	82	312
Cousins	..	..	23	44	Koons	..	..	52	71
Dafter	7	19	9	13	Kotsakis	9	61	..	..
Epstein	..	..	3	62	Kouts	28	33	3	3
Fernald	141	226	204	455	Luft	25	21	20	76
Flower	6	11	14	14	Marsh	2	2	..	..
Chandra	102	145	129	162	Mary	24	31	24	33
Cilley	35	93	25	48	Matthews	..	..	3	263
Focas	7	7	..	..	Mayall	2	10	1	5
Gossner	15	53	1	13	Mount	5	9	7	21
Halbach	..	..	30	54	Nadeau	53	55	87	123
Harris	24	24	25	25	Oheim	41	49	62	112
Hartmann	130	148	118	153	Oravec	25	101	29	79
Helfer	..	..	3	20	Parker	25	25	23	25

Observer	March—1946—April No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	March—1946—April No. Var.	No. Ests.	No. Var.	No. Ests.
Parks	14	23	18	37	Strauss	..	..	3	41
Peltier	97	147	128	179	Taboada	31	31	52	52
Petzold, H. E.	6	6	14	20	Tarbell	2	18	..	..
Petzold, H. R.	47	170	40	96	Topham	..	..	79	79
Renner	33	33	47	51	Webb	17	25	20	23
Robinson, H.	..	..	1	1	Weber	20	20	30	30
Rosebrugh	18	101	22	130	Weitzenhoffer	..	..	2	26
Schoenke	..	..	12	12	Welker	10	10	10	12
Segers	..	..	23	73	Zirin	35	36	..	..
Sill	..	..	42	51					
Stowe	7	8	..	..	66 Totals	2,860		3,887	

May 14, 1946.

General Notes

Dr. Wasley Krogdahl of Yerkes Observatory has been appointed Instructor in Astronomy at Dearborn Observatory of Northwestern University.

Dr. Otto Struve, well known as the Director of the Yerkes and McDonald Observatories, has been honored by the University of Chicago which has appointed him to the Andrew MacLeish Distinguished Service Professorship. Dr. Struve has also recently been elected Foreign Member of the Royal Danish Academy of Sciences and Letters.

Dr. Paul W. Merrill, of the Mount Wilson Observatory, has been awarded the Catherine Wolfe Bruce Gold Medal for the year 1946, as announced recently by Dr. F. J. Neubauer, retiring president of the Astronomical Society of the Pacific. Dr. Neubauer concluded his remarks in making the award with the following paragraph:*

"Dr. Merrill's name now appears in the roster of our Society with thirty-eight other names of distinguished astronomers and scientists known to all the world. We wish to congratulate him and to express our sincerest hope that he derives the joy that this distinction is meant to convey to him. We are proud to claim him, together with Stanford University, with the Lick Observatory of the University of California, and with the Mount Wilson Observatory of the Carnegie Institution of Washington, as one of California's outstanding adopted men of science."

According to the *Science News Letter* for May 4, 1946, Dr. Merrill has also received the Henry Draper medal awarded by the National Academy of Science for numerous important contributions, in particular those on stellar spectroscopy.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on May 10, 1946. Dr. Arnold Dresden, Professor of Mathematics, Swarthmore College, addressed the meeting on the topic, "The Realm of Orbits."

*P. A. S. P., **58**, 85.

Polish Astronomers—War Victims

The almost unbelievable suffering which the war inflicted on many persons is indicated by the following excerpt from a letter by Professor Fel. Kepinski of the Polytechnical Institute of Astronomy, Warsaw, to Professor G. Van Biesbroeck:

"All the scientific work that I had under way (13 papers) was burned. A son who was aviator with the R.A.F. was killed in action. I lost one eye by a bomb explosion. I also feel deeply the loss of Dr. M. Kowalczewski, assistant, who was a victim of German atrocities. The Institute does not exist any more as an observatory. No trace of the instruments which were stolen before the city burned. Only part of our publications were saved."

The Cleveland Astronomical Society

Dr. J. S. Hall of the Radiation Laboratory, Massachusetts Institute of Technology, addressed the meeting of the Cleveland Astronomical Society on May 3. His topic was "Navigation with Radar."

Dr. Hall not only discussed the general principles, possibilities, and limitations of radar but also did the same for the electronic aid to navigation called Loran. The term is derived from the words *LOng RAnge Navigation*. Its outstanding characteristic is its ability to furnish positions to navigators at greater distances from the transmitting stations than can be achieved through other method of radio navigation. It is comparable in accuracy with that of celestial navigation and can be accomplished under almost any kind of weather conditions.

At the end of the lecture two interesting motion picture films of radar in operation were projected. Especially interesting were the pictures showing the indications and changes on the radar scope as a bomber flew over Boston and other familiar cities in Eastern United States.

HENRY F. DONNER.

Western Reserve University, Cleveland 6, Ohio.

Report of the Solar Division of A.A.V.S.O.

The following items are extracted from the Report of the Solar Division of A.A.V.S.O., covering the six months period, November, 1945, to April, 1946, inclusive, given by the chairman, Neal J. Heines, at the Spring Meeting held at Smith College on May 4, 1946.

CONDITIONS OF THE PRESENT SOLAR CYCLE

In comparison to the previous sun-spot cycle, 1933-44, the Preliminary Relative Sun-spot Numbers of the present cycle show generally higher values.

The greatest amount of activity has been in the south belt in so far as Group Count is concerned. However, according to a statement by Dr. Brunner, former Director of the Federal Observatory, Switzerland, in a letter to your chairman in 1935, Belt activity equalizes itself in most every sun-spot cycle.

The North Belt has had the most phenomenal group, however, the details of which are as follows:

1. The largest Sun-spot Group ever photographed since the photographic program had its inception.

2. The overall length was about 200,000 miles.
3. The leader spot was about 50,000 miles across.
4. The follower spot was at one time almost 100,000 miles across.
5. It was situated in high heliocentric latitude.

The appearance of the Aurora Borealis in the lower latitudes has made an unusually early appearance.

High Flying Migratory Birds Crossing the Solar Disc

This has come about through the kind assistance, and request for data, from Dr. William A. Rense, Physicist, and Dr. George N. Lowery, Jr., Ornithologist, both of the Louisiana State University. Dr. Rense's article "Astronomy and Ornithology" in Popular Astronomy, February Issue, prompted action.

The earliest record of an official report on the observation of high flying migratory birds, according to the New York Public Library, appeared in *Nature*, August 29, 1895, p. 415, under the title of "A Remarkable Flight Of Birds." It reads as follows:

"On September 30, 1894, about 3 P.M., I was observing the Sun through an 8-inch telescope. I noticed some dark figures of birds passing, like shadows, across the sun. I was using a dark glass, and the birds were, consequently, only visible when seen against the bright solar disc. The silhouettes of the birds were very sharply and clearly cut. Every few seconds a bird would emerge from the darkness, pass slowly across the sun and disappear on the other side. I watched them for over ten minutes without any decrease in their numbers. The whole number of birds must have been enormous, otherwise it would have been impossible for some of them to have passed as frequently as they did between my telescope and the sun. The birds were flying in a southerly direction, and were quite invisible to the naked eye. I was, therefore, unable to determine their distance, but should think they must have been two or three miles away, for the telescope was in focus for the birds and the sun at the same time. I do not know what birds they were. Comparing the spread of their wings with the solar disc, I should say their wings subtended an angle of about two minutes. The place from which I observed them was Shere, a village between Guilford and Dorking. I am told that such a flight of birds has not before been recorded in this country, and have been advised and urged to publish an account in the hope that other astronomers, who may have seen a similar thing, may be led to mention the fact.

R. A. Bray."

Shere, England.

Your chairman first observed birds crossing the solar disc in 1935 and became deeply interested. Observations continued during both migratory periods each year and records were kept of the observations. The war period did not allow the same amount of time for such observations, nevertheless it was managed to secure some data by observation.

In a recent letter, Dr. Lowery has this to say, "The matter of making observations of birds crossing before the lunar and solar discs seems to me to be the means whereby we can solve some of the greatest problems in bird migration. I cannot over-emphasize the importance of getting others to co-operate in as many localities as possible."

Sun-spots Photographed

The Reverend Mr. Kearons has resumed his photographic work on sun-spots. His photograph of No. 46117 is to be used in a report to the Government from the Carnegie Institution incorporating the work of the Solar Division and the procedures of treatment to data supplied by the A.A.V.S.O. Solar Division.

Membership

The Solar Division had as of May 1, 1946, 68 members, fifty-four of whom are sending in reports monthly. This is a net gain of six members since the last report of October 6, 1945. We have lost eight but have fourteen new members. Twenty-two states of the U. S., two countries in South America, one observer in Australia, and the University of Athens, Greece, comprise the distribution of membership.

Number of Observations

The number of observations involved in the reports submitted since September 30, 1945, is 3139 making a total since the inception of the Solar Division 8923.

Midwest Group of Astronomers

At the kind invitation of Professor O. J. Lee, a meeting of the Midwest Group was held at Northwestern University on May 18. The program was a very full one, devoted to novel types of apparatus for astronomical observation. During the war the progress in electronic techniques has led to applications of radar, electron-multiplier tubes, and infrared devices. Radiation from the sun and the Milky Way was detected, and new quantitative measures became available as a result of war research. The electron-multiplier tube, in particular, has become an extremely useful device. The meeting was attended by fifty astronomers, physicists, and amateurs. The Secretary will be glad to hear from those interested in receiving notices of future meetings.

Papers given include:

Radio Observations of Astronomical Objects—Grote Reber, Wheaton, Ill.

Radiation from the Sun and the Milky Way—Jesse L. Greenstein, Yerkes Observatory.

Theory of Cosmic Static—Louis G. Henyey, Yerkes Observatory.

Results with Electron-Multiplier Tubes—A. E. Whitford, Washburn Observatory.

New Infrared Techniques—R. J. Cashman, Northwestern University.

Planetary Photography—G. P. Kuiper, Yerkes Observatory.

New Infrared Spectra—G. Herzberg and W. A. Hiltner, Yerkes Observatory.

Polarization in Astrophysics—S. Chandrasekhar, Yerkes Observatory.

Jesse L. Greenstein, *Secretary.*

Yerkes Observatory, Williams Bay, Wisconsin.

A Prophecy.—Under this phrase, *The Observatory* for February, 1946, calls attention to some lines written by Pierre de Ronsard (1524-1585), thereby implying that as a prophecy it is fulfilled in our time. The lines are

"Quand tu naquis, Edinton, tous les cieux
Mirent en toi toute leur harmonie,"

the English equivalent of which is

When you were born, Edinton, all heaven
Put all its harmony in you.

Book Reviews

Optical Instruments, by Earle B. Brown (Chemical Publ. Co., 234 King Street, Brooklyn, New York. $10.00).

This is a book which the reviewer believes should be in the hands of most seriously-minded students of optics and makers of optical instruments. The author is well known, to amateur telescope-makers at least, through his numerous articles written under the heading "Gleanings for A.T.M.'s."

The book is divided into four main sections, Part I, dealing with the Principles of Geometric Optics; II, Description, Operation, and Theory of Optical Instruments; III, Construction and Maintenance of Optical Instruments; IV, Supplementary Topics.

In Part I, the author deals extensively with the nature of light, particularly as it pertains to lenses, prisms, and the eye. The subject of reflection and refraction is well covered, besides a rather thorough description of eyepieces and other optical accessories.

Part II discusses the principles involved in the practical features of instruments, not only of the telescope, but also of cameras, microscopes, projectors, spectroscopes, surveying instruments, range finders, and military instruments. The third part devotes some fifty pages to the construction and maintenance of various types of optical instruments. In the fourth section such topics as the design of optical systems, manufacture of optical glass, and notes on physical optics are considered.

There follow two appendices, the first dealing with mathematical proofs, and the second, a very comprehensive glossary of optical terms, a feature of real value, especially to the amateur telescope-maker and user.

The book is well illustrated throughout with excellent diagrams and drawings, and, although it does not contain full details as to the construction of optical instruments, especially telescopes of the reflecting type, it does present to the layman much valuable information in this field.

"Optical Instruments" could well be used as a textbook for students in schools and colleges, industrial plants, and optical clubs. The book, although not entirely devoid of errors, still offers to the interested reader a helpful source of information on a subject concerning which not too much has been made readily available under one cover to the non-technical person.

L.C.

To the Editor of Popular Astronomy:

We are much indebted to Professor Smiley for pointing out certain errors in the revised edition of our "Astronomy."[1] They will be corrected in the next printing.

It may be appropriate to mention that the classical designations of the equinoxes were retained deliberately. We do not desire to describe Sidereal time as the hour angle of the March equinox!

The remark on page 228 about the number of eclipses in a Saros is a correct

[1] Popular Astronomy, **54**, 105, February, 1946.

statement of the average number of times that a solar eclipse is repeated at intervals of a Saros. The average number of such eclipses in a single Saros is 43, as Smiley states. This is described in full detail in Young's General Astronomy, pp. 264-65. Abbreviation demands eternal vigilance—a virtue which Professor Smiley possesses—having caught a slip which escaped the authors and every one else for twenty years.

He has however overestimated the effect of a change in the adopted solar parallax on the length of the shadows of the earth and moon. The semi-angle of the cone of the earth's umbra is S-p, when S is the sun's semi-diameter and p the solar parallax; and its length is R cosec (S-p) when R is the earth's radius. (For proof, see again Young's General Astronomy, p. 251.)

Jones' new value changes p by —0".013, but does not alter S or R. Since S = 959".65, S-p is changed by one part in 73,000 and the length by the shadow by 12 miles—a wholly negligible amount. For the moon p must be taken as the solar parallax in terms of the moon's radius, and the change in the computed length of the shadow is $(0.273)^2$ times that for the earth, or less than a mile!

HENRY NORRIS RUSSELL.

Princeton, New Jersey, May 7, 1946.

POPULAR ASTRONOMY

CONTENTS

JUNE, 1946

GERMAN ASTRONOMY DURING THE WAR, GERARD P. KUIPER..... 263

THE DEVELOPMENT OF ASTRONOMICAL PHOTOMETRY (CONTINUED), HAROLD F. WEAVER..... 287

The Planets in July and August, 1946..... 299

Occultation Predictions for July and August, 1946..... 300

Asteroid Notes 302

Comet Notes 303

Periodic Comet Tempel II,—Comet Timmers (1946 *a*),—Comet Brooks,—Comet Giacobini-Zinner.

Meteors and Meteorites 305

Meteor notes from the American Meteor Society,—Contributions of the Society for Research on Meteorites: The abundance of the chemical elements in meteorites and tektites; A decisive test for the presence of even a highly rarefied lunar atmosphere; Comments on paper by Professor M. A. R. Khan; Interplanetary meteorites and minor planets; Extrasolar or interstellar meteorites; Preliminary notice of the ninth meeting of the Society.

Variable Stars 316

Variable Star Notes from the American Association of Variable Star Observers.

General Notes 320

Personal notices, — The Rittenhouse Astronomical Society, — Polish astronomers—war victims,—The Cleveland Astronomical Society; Report of the Solar Division of the A.A.V.S.O.,—Midwest group of astronomers,—A prophecy.

Book Reviews 324

Optical Instruments,—Letter to the Editor.

The principal articles of this magazine, beginning with Volume 15 (1907), are listed in the INTERNATIONAL INDEX TO PERIODICALS.